Species Status Assessment Report for Colorado hookless cactus (*Sclerocactus glaucus* and *Sclerocactus dawsonii*)

Prepared by the Western Colorado Field Office
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EXECUTIVE SUMMARY

This species status assessment (SSA) report communicates the results of the comprehensive biological status review by the U.S. Fish and Wildlife Service (Service) for Colorado hookless cactus. Since 1966, when the species was assigned to the genus *Sclerocactus*, *Sclerocactus glaucus* has undergone a series of taxonomic revisions. The most recent genetic analyses determined that the Colorado hookless cactus found in western Colorado represent two distinct species: *S. glaucus* and *S. dawsonii*. Based on these novel discoveries, this SSA assesses the current and future condition of Colorado hookless cactus as these two separate entities.

S. glaucus and *S. dawsonii* are endemic cactus species found in the Colorado and Gunnison River basins and their tributary canyons in Garfield, Mesa, Montrose, and Delta Counties in western Colorado. The species occur on alluvial benches and colluvial slopes from 4,500 to 7,200 feet (1,372 to 2,195 meters) in semi-arid high elevation desert. *S. glaucus* occurs in eight analytical units (AUs) in a range that extends from the Grand Valley, through the high desert at the foot of the Grand Mesa, and along the alluvial terraces of the Gunnison River and the Dominguez and Escalante Creek drainages to near Montrose. *S. dawsonii* occurs in two AUs along the Colorado River from DeBeque downstream toward the Grand Valley and along the Roan and Plateau Creek drainages.

To evaluate the biological status of Colorado hookless cactus both currently and into the future, we assessed a range of factors to consider the species' resiliency, redundancy, and representation (together, the 3Rs). Both species need (1) a sufficient number and distribution of resilient AUs to withstand catastrophic events (redundancy) and (2) a range of variation that allows the species to adapt to changing environmental conditions (representation). To be resilient, AUs of both species require survivorship and recruitment at rates that are able to sustain AUs with pollinator connectivity between individuals and clusters of plants within the AU. Resilient AUs also contain enough individuals across each life stage (seed, seedling, and mature reproductive adult) to bounce back after experiencing environmental stressors such as intermediate disturbance, occasional drought, or grazing. Finally, individuals in both species of Colorado hookless cactus need certain habitat factors for resiliency. These include shallow exposed sandy or shale soils of sedimentary parent material or gravelly deposits of river alluvium; a semi-arid, high elevation desert climate (1,372-2,195 m) with 8-12 inches rain per year; and a period of deep cold during winter months to facilitate germination the following spring. Colorado hookless cactus redundancy is influenced by the number of AUs across the landscape. More AUs across the range of Colorado hookless cactus increase the species' ability to withstand catastrophic events. Individuals and AUs inhabiting diverse ecological settings and exhibiting genetic or phenological variation add to the level of representation across the species' range. The greater diversity observed in Colorado hookless cactus genetics, habitats, and morphology, the more likely it is to be able to adapt to change over time.

In this SSA, we evaluate a number of stressors and conservation efforts and their influence on the resiliency of *S. glaucus* and *S. dawsonii*. Stressors include livestock use, invasive species, oil and gas development, OHV recreational use, predation, development and maintenance of utility corridors, the effects of global climate change, herbicide and pesticide application, and collection

and commercial trade. We then evaluated current and projected future conditions by assessing habitat, demographic, and climate metrics in relation to the extent that the needs of the species are being or will be met.

Currently, *S. dawsonii* has a minimum of 31,867 plants distributed across two highly resilient AUs with a high survival rate and moderate to high habitat conditions across the range of the species. *S. glaucus* currently has a minimum of 103,086 plants distributed across eight AUs. Seven of the eight AUs are highly resilient; one is ranked moderate. Across their limited ranges, both species of Colorado hookless cactus are relatively abundant, which contribute to the high levels of resiliency in all but one AU. Redundancy for narrow endemic species is inherently limited; however, *S. glaucus* plants are distributed broadly across the range of the species in eight AUs, providing redundancy throughout its relatively small geographic range. With only two AUs located within a smaller range than *S. glaucus*, redundancy of *S. dawsonii* is much lower than that of *S. glaucus*. *S. glaucus*'s relatively broad distribution and multiple highly resilient AUs make it better able to withstand catastrophic events than *S. dawsonii*. Representation is comparable among *S. glaucus* and *S. dawsonii*. Both species exhibit little ecological and morphological variability, coupled with low to moderate genetic diversity among AUs. However, inbreeding is not an immediate concern for either species.

In a Pessimistic future scenario, future development, and incompatible uses of *S. glaucus* and *S. dawsonii* habitat have the potential to reduce the resiliency of most AUs. A hot and dry climate scenario could also reduce resiliency, although we are unsure to what extent. With only two known *S. dawsonii* AUs, the loss of one of these AUs due to catastrophic, natural, or human-caused events would cause a severe loss of redundancy and representation of the species, though a complete loss is not expected even in a Pessimistic scenario. Under Optimistic and Continuation scenarios, resiliency is expected to remain high for both *S. dawsonii* AUs and seven of the eight *S. glaucus* AUs. Redundancy and representation are inherently low in narrow endemic species; however, even in our most pessimistic scenario, we anticipate all AUs of both species to remain extant, thereby preserving current levels of representation and redundancy of each species.

Table of Contents

List of Tables

List of Figures

CHAPTER 1: BACKGROUND AND ANALYTICAL FRAMEWORK

1.1 INTRODUCTION

Sclerocactus glaucus was first listed under the ESA in 1979 (44 FR 58868, October 11, 1979) as a threatened species. In 2009 (74 FR 47113, September 15, 2009), it was determined that *Sclerocactus glaucus*, as listed, was three separate species: *Sclerocactus brevispinus* (Pariette cactus), *Sclerocactus glaucus* (Colorado hookless cactus), and *Sclerocactus wetlandicus* (Uinta Basin hookless cactus). Previously, these three species were scientifically classified under the single scientific name of *Sclerocactus glaucus* (Benson 1966, pp. 50-57; 1982, pp. 728-729). All three of these species retained their threatened status in this 2009 determination; thus, the Colorado hookless cactus is currently listed as a threatened species under the ESA. The term "threatened species" means any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range (16 U.S.C. 1531-1544, 87 Stat. 884, 3.20)

We conducted this SSA to compile the best scientific and commercial data available regarding the species' biology and factors that influence the species' viability. This SSA report will be the biological underpinning of the Service's forthcoming 5-year status review, draft recovery plan, and final recovery plan for the species. We intend this report to support all functions of our Endangered Species Program and we will update as new information becomes available. As such, the SSA report will be a living document upon which we will base other future documents, such as listing rules, recovery plans, and 5-year status reviews. The SSA process and this SSA report do not represent a regulatory decision by the Service under the ESA. Instead, this report provides a review of the best available information strictly related to the biological status of Colorado hookless cactus and our scientific evaluation of its current and future condition.

1.2 ANALYTICAL FRAMEWORK

This report is a summary of the SSA analysis, which entails three iterative assessment stages (Figure 1):

1. **Species Ecology.** An SSA begins with a compilation of the best available biological information on the species (taxonomy, life history, and habitat) and its ecological needs at the individual, population, and species levels, based on how environmental factors are understood to act on the species and its habitat.

2. **Current Species Condition.** Next, an SSA describes the current condition of the species' habitat and demographics and the probable explanations for past and ongoing changes in abundance and distribution within the species' ecological

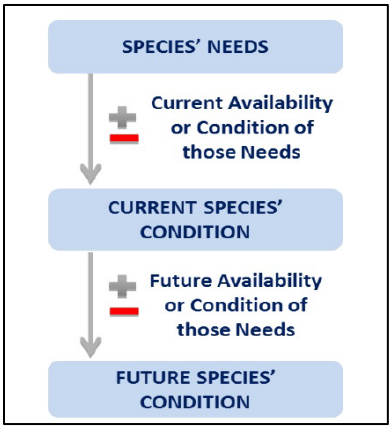

Figure 1. Species status assessment stages. Source: USFWS 2016

settings (i.e., areas representative of the geographic, genetic, or life history variation across the species range).

3. **Future Species Condition.** Lastly, an SSA forecasts the species' response to probable future scenarios of environmental conditions and conservation efforts. As a result, the SSA characterizes a species' ability to sustain populations in the wild over time (viability) based on the best scientific understanding of current and future abundance and distribution within the species' ecological settings.

Viability is the ability of a species to maintain populations in the wild over time. To assess viability, we use the conservation biology principles of resiliency, redundancy, and representation (Shaffer and Stein 2000, pp. 308-311). To sustain populations over time, a species must have the capacity to withstand:

(1) environmental and demographic stochasticity and disturbances (Resiliency),
(2) catastrophes (Redundancy), and
(3) novel changes in its biological and physical environment (Representation).

A species with a high degree of resiliency, representation, and redundancy (the 3Rs) is better able to adapt to novel changes and to tolerate environmental stochasticity and catastrophes. In general, species viability will increase with increases in resiliency, redundancy, and representation (Smith *et al*. 2018, p. 306).

Resiliency is the ability of a species to withstand environmental stochasticity (normal, year-to-year variations in environmental conditions such as temperature, rainfall), periodic disturbances within the normal range of variation (fire, floods, storms), and demographic stochasticity (normal variation in demographic rates such as mortality and fecundity) (Redford *et al*. 2011, p. 40). Simply stated, resiliency is the ability to sustain populations through the natural range of favorable and unfavorable conditions.

We can best gauge resiliency by evaluating population level characteristics such as: demography (abundance and the components of population growth rate – survival, reproduction, and migration), genetic health (effective population size and heterozygosity), connectivity (gene flow and population rescue), and habitat quantity, quality, configuration, and heterogeneity. For species prone to spatial synchrony (regionally correlated fluctuations among populations), distance between populations and degree of spatial heterogeneity (diversity of habitat types or microclimates) are also important considerations.

Redundancy is the ability of a species to withstand catastrophes. Catastrophes are stochastic events that are expected to lead to population collapse regardless of population heath and for which adaptation is unlikely (Mangal and Tier 1993, p. 1083).

We can best gauge redundancy by analyzing the number and distribution of populations relative to the scale of anticipated species-relevant catastrophic events. The analysis entails assessing the cumulative risk of catastrophes occurring over time. Redundancy can be analyzed at a population or regional scale, or for narrow-ranged species, at the species level.

Representation is the ability of a species to adapt to both near-term and long-term changes in its physical (climate conditions, habitat conditions, habitat structure, etc.) and biological (pathogens, competitors, predators, etc.) environments. This ability to adapt to new environments – referred to as adaptive capacity – is essential for viability, as species need to continually adapt to their continuously changing environments (Nicotra *et al*. 2015, p. 1269). Species adapt to novel changes in their environment by either (1) moving to new, suitable environments or (2) by altering their physical or behavioral traits (phenotypes) to match the new environmental conditions through either plasticity or genetic change (Beever *et al*. 2016, p. 132; Nicotra *et al*. 2015, p. 1270). The latter (evolution) occurs via the evolutionary processes of natural selection, gene flow, mutations, and genetic drift (Crandall *et al*. 2000, p. 290-291; Sgro *et al*. 2011, p. 327; Zackay 2007, p. 1).

We can best gauge representation by examining the breadth of genetic, phenotypic, and ecological diversity found within a species and its ability to disperse and colonize new areas. In assessing the breadth of variation, it is important to consider both larger-scale variation (such as morphological, behavioral, or life history differences which might exist across the range and environmental or ecological variation across the range), and smaller-scale variation (which might include measures of interpopulation genetic diversity). In assessing the dispersal ability, it is important to evaluate the ability and likelihood of the species to track suitable habitat and climate over time. Lastly, to evaluate the evolutionary processes that contribute to and maintain adaptive capacity, it is important to assess (1) natural levels and patterns of gene flow, (2) degree of ecological diversity occupied, and (3) effective population size. In our species status assessments, we assess all three facets to the best of our ability based on available data.

CHAPTER 2: SPECIES BIOLOGY, LIFE HISTORY, AND DISTRIBUTION

2.1 TAXONOMY

Colorado hookless cactus is a member of the Cactaceae and was first described by C.A. Purpus in 1892 from plants collected in the Gunnison River basin. In 1966, the species was assigned to the genus *Sclerocactus* by L.D. Benson (Benson 1966, pp. 50-57). Since then, *Sclerocactus glaucus* has undergone a series of taxonomic revisions. When listed, the range of *Sclerocactus glaucus* was considered to include western Colorado and northeastern Utah (Uintah Basin hookless cactus complex). The re-evaluation of morphological characters, phylogenetic studies, and common garden experiments led to the determination that the Uinta Basin hookless cactus complex was in fact three distinct species: *Sclerocactus glaucus* (Colorado hookless cactus), *Sclerocactus brevispinus* (Pariette cactus), and *Sclerocactus wetlandicus* (Uinta Basin hookless cactus) (Heil and Porter 2004, pp. 197-207; Hochstätter 1993, pp. 82-92). *Sclerocactus glaucus* was determined to be restricted to the Colorado and Gunnison River basins in western Colorado, while *Sclerocactus brevispinus* and *Sclerocactus wetlandicus* are limited to the Uinta Basin in eastern Utah. In 2009, the Service published a final rule recognizing and accepting this revised

taxonomy of the three species and determined that all three species would continue to be listed as threatened (74 FR 47112, September 15, 2009).

In 2017, genetic studies identified three distinct regional groups of Colorado hookless cactus: Northern, Grand Valley, and Gunnison River groups (Schwabe *et al*. 2015, p. 447, McGlaughlin and Ramp-Neale 2017, p. 5). The most recent genetic analyses, using Random Site-Associated DNA sequencing (RADseq), determined that the Northern group should be recognized as a distinct species, hereafter *Sclerocactus dawsonii*, or *S. dawsonii* (McGlaughlin and Naibauer 2021, entire). The Grand Valley and Gunnison River groups share connectivity and form a genetically cohesive group, which represents a second distinct species, hereinafter collectively referred to as *Sclerocactus glaucus*, or *S. glaucus* (McGlaughlin and Naibauer 2021, p. 3). Based on these novel genetic discoveries, this SSA will assess the current and future condition of Colorado hookless cactus as two separate entities: *S. glaucus* and *S. dawsonii*. However, given the recent nature of this taxonomic information, most literature on the species draws conclusions regarding both *S. glaucus* and *S. dawsonii* without distinguishing between the two; for example, research regarding species needs covers both entities, since they were a single species at the time of this research. Thus, when we use the common name "Colorado hookless cactus," we are referring to information or conclusions regarding both species (*S. glaucus* and *S. dawsonii*). When we are referring to information or analysis pertaining to one species, we will use the new scientific names of *S. glaucus* and *S. dawsonii*.

Kingdom	Plantae
Phylum	Tracheophyta
Class	Magnoliopsida
Order	Caryophyllales
Family	Cactaceae
Genus	Sclerocactus
Species	Glaucus
	Dawsonii

Figure 2. Taxonomic description of Colorado hookless cactus (ITIS 2017).

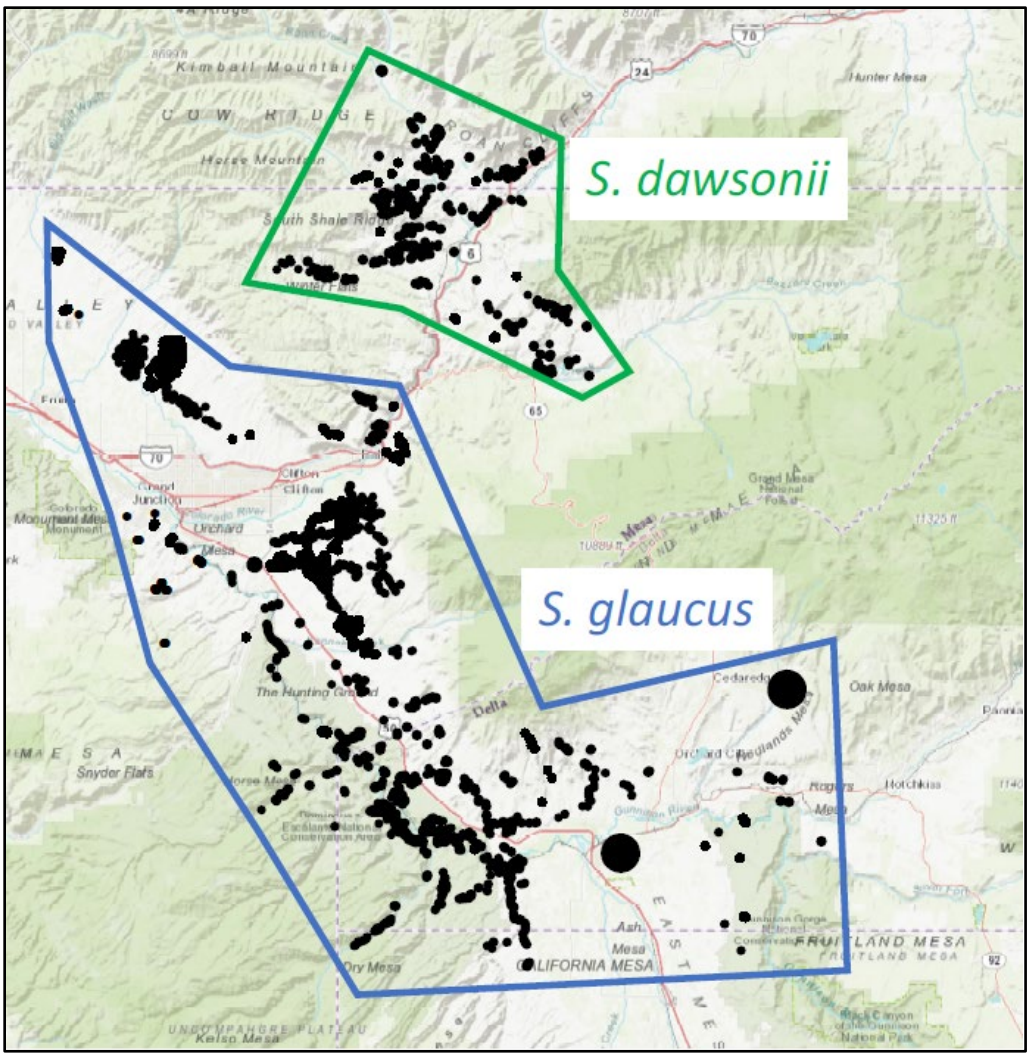

Figure 3. Known distribution of S. dawsonii and S. glaucus in western Colorado (McGlaughlin and Naibauer 2021, p. 21)

2.2 Analytical Units

To discern the nuances in conditions that occur across the ranges of the species and stressors that are influencing these conditions, we analyze the resiliency, redundancy, and representation of the Colorado hookless cactus in 10 representative analytical units (AUs). Boundaries for these AUs include all occupied habitat and are delineated by natural geological and ecological features as well as management boundaries. Within each AU are multiple clusters of cacti and all known plant occurrences are located within the boundaries of the 10 AUs. Analytical Units were chosen for this analysis, rather than define populations for each species, to avoid confusion with past definitions of Colorado hookless cactus populations used in literature that predates the taxonomic split of *S. glaucus* and *S. dawsonii*.

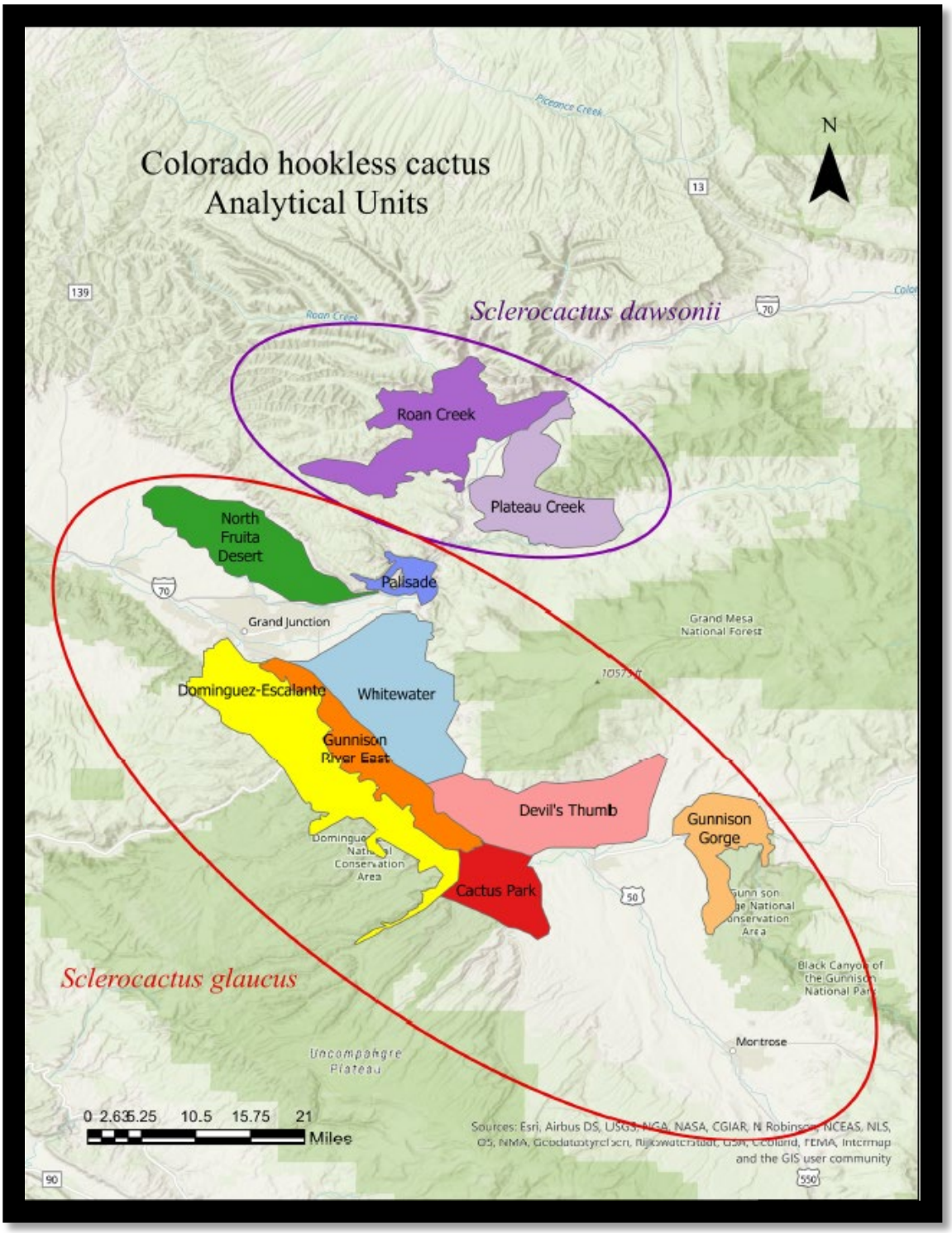

Figure 4. Map of the ten analytical units used to analyze Colorado hookless cactus resiliency, redundancy, and representation.

Table 1. Description of the size of each Colorado hookless cactus analytical unit.

Species	Analytical Unit	Acres	sq mi	sq km
S. glaucus	Cactus Park	28,702	45	116
	Devil's Thumb	65,632	103	265
	Dominguez-Escalante	84,592	132	342
	Gunnison Gorge	30,829	48	125
	Gunnison River East	37,570	59	152
	North Fruita Desert	49,721	78	201
	Palisade	9,269	15	38
	Whitewater	73,033	114	296
	Total *S. glaucus*	**379,348**	**593**	**1,535**
S. dawsonii	Plateau Creek	47,849	75	194
	Roan Creek	64,874	101	263
	Total *S. dawsonii*	**112,723**	**176**	**456**

2.3 SPECIES DESCRIPTION

S. glaucus and *S. dawsonii* are morphologically indistinguishable and can only be identified from one another by genetic analysis or location. Therefore, the species description is the same for both species. The description is based on those by Heil and Porter (2004, pp. 200-201) as used in the *Flora of North America* and those by Hochstatter (2005, pp. 14-18, 37-38) (USFWS 2009, p. 47114).

Plant Description: Leafless, stem-succulent plant with short cylindrical to ovoid body, usually 3 to12 cm (1.2 to 4.8 in) tall, but up to 30 cm (12 in) tall; 4 to 9 cm (1.6 to 3.6 in) diameter; with 8 to 15 (usually 12 or 13) tubercle-bearing ribs. **Spines:** Spines occur in clusters within the areoles at tip of tubercles. **Areoles**: Pubescent in juvenile individuals. **Radial Spines:** 2 to 12 (usually 6 to 8) per cluster; white or gray to light brown; up to 17 millimeters (mm) (0.67 in) long; less than 1 mm (0.04 in) in diameter. **Central Spines**: Longer and heavier than radial spines; numbering one to five (usually three: one abaxial and two lateral), 12 to 50 mm (0.5 to 2.0 in) long, and 0.8 to 1.8 mm (0.03 to 0.07 in) thick. **Abaxial Spines:** Usually solitary (sometimes lacking) and ascending toward the apex of the plant body with its tip noticeably bent at an angle usually less than 90 degrees. **Lateral Spines:** Usually displayed in pairs on either side of the abaxial spine; they are of approximately the same length and thickness but are relatively straight without obvious bent tip of the abaxial spine; these diverge from abaxial spine at an acute angle, usually between 20 and 50 degrees. **Flowers:** Fragrant and funnelform (funnel-shaped) or rarely campanulate (bell-shaped), 3 to 6 cm (1.2 to 2.4 in) long, and 3 to 5 cm (1.2 to 2.0 in) in diameter. **Tepals:** Consist of two whorls. Outer: 20 to 30 tepals; have broad, greenish-lavender midstripe with pink margins, and are oblanceolate; tepals transition from small, leaf-like scales low on the floral tube to petal-like structures near rim of floral tube; are 4 to 30 mm (0.16 to 1.2 in) long and 4 to 6 mm (0.16 to 0.24 in) wide. Inner: 12 to 20 tepals, pale pink to dark pink, oblanceolate to lanceolate, and 25 to 35 mm (1 to 1.4 in) long and 4 to 6 mm (0.16 to 0.24 in)

wide; borne at rim of floral tube. **Stamens:** Numerous, have yellow anthers attached by filaments (from green to white) to the interior surface of the floral tube. **Floral Tube:** Arises from upper margin of the seed-producing ovary. **Ovary:** Bears one style (from pink to yellow) with stigma of about 12 lobes. After pollination, ovary ripens into dry fruit in approximately 4 to 6 weeks, with 15 to 30 seeds turning from green to brown. **Fruit:** Ovoid, barrel-shaped, reddish, or reddish grey when ripe, 9 to 30 mm (0.35 to 1.2 in) long (usually less than 22 mm (0.87 in) long), and 8 to 12 mm (0.31 to 0.47 in) wide. **Seeds:** Black, asymmetrically elongated, with hilum (seed scar at point of attachment to ovary wall) near side of smaller seed lobe; 1.5 mm (0.06 in) wide and 2.5 mm (0.1 in) long; testa (seed coat) covered by rounded papillae.

2.4 Phenology and Reproduction

Plants usually flower in late April and early May and are readily visible due to their conspicuous, pink flowers (Table 2). Once flowering is complete, plants become more difficult to see due to their dull greyish color.

Pollinator assisted outcrossing (xenogamy) is the primary mode of genetic exchange for the Colorado hookless cactus (Janeba 2009, p. 67; Tepedino *et al*. 2010, p. 382). Numerous studies have documented that pollinators visit the flowers of cacti belonging to the genus *Sclerocactus* (Tepedino *et al*. 2010, p. 380). Researchers examined the breeding system of Colorado hookless cactus and two closely related *Sclerocactus* species in Utah and showed that pollinators are necessary for sexual reproduction (Tepedino *et al*. 2010, p. 382). This research also demonstrated that plants produced a greater amount of seeds via outcrossing than self-fertilization (Tepedino *et al*. 2010, p. 381).

In rare cases, individual plants may consist of more than 10 extant stems originating from a single root mass branching beneath the surface of the soil (BLM 2020, p.16-17). This was most found in cacti with mild to moderate tissue damage from trampling or crushing (BLM 2020, p.16-17). Resembling a tight bunch of individual cactus buttons, plants may also germinate in clumps adjacent to, or at the base of a mature plant. Findings of over fifty individual buttons at the base of a mature individual has been documented (BLM 2020, p.16-17). It is impossible to know if these findings are the stems of individual plants or a cluster of distinct plants without excavating the plant (BLM 2020, p.16-17). These plants are likely several closely related (not genetically identical) individual plants that, through competition, are reduced over time and resulting in one or two persistent individuals (BLM 2020, p.16-17).

Table 2. Gantt chart illustrating the life stage of Colorado hookless cactus.

Life stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												
Fruits Mature												
Seed												
Germination												
Dormancy												

2.5 HABITAT

Colorado hookless cactus is an endemic cactus known from Delta, Garfield, Mesa and Montrose counties in western Colorado (CNHP 2014). The species occurs from 4,500 to 7,200 feet (1,372 to 2,195 meters) in the semi-arid high elevation deserts of the western slope of Colorado (Heil and Porter 2004, p. 200; Holsinger 2021, pers. comm.).

Colorado hookless cactus are primarily found on alluvial benches along the Gunnison and Colorado Rivers and their tributaries. Colorado hookless cactus occurs on rocky or gravelly surfaces on river terrace deposits and lower mesa slopes and tend to be more abundant on south facing slopes. In general, Colorado hookless cactus occurs in coarse, gravelly deposits of river alluvium or shallow exposed sandy or shaley soils of sedimentary parent material (CNHP 2014). The species displays a patchy, generalist distribution and has been found to grow primarily in small, discrete colonies of individuals in various upland desert habitat and communities (BLM 2020, p. 18).

Typical desert scrub dominated by shadscale (*Atriplex confertifolia*), galleta (*Hilaria jamesii*), black-sage (*Artemisia nova*), and Indian rice grass (*Stipa hymenoides*) is associated with Colorado hookless cactus along with kingcup cactus (*Echinocereus triglochidiatus var. triglochidiatus*) and Simpson's pincushion cactus (*Pediocactus simpsonii*). Some other species in the associated plant community include the prickly pear cactus (*Opuntia polyacantha*), winterfat (*Krascheninnikovia lanata*), yucca (*Yucca harrimaniae*), snakeweed (*Gutierrezia sarothrae*), yellow rabbitbrush (*Chrysothamnus viscidiflorus*), sand dropseed (*Sporobolus cryptandrus*), and Salina wildrye (*Elymus salinus*) (USFWS 2010, p. 3). Typically, fire is not a characteristic of Colorado hookless cactus habitat, but a buildup of fuels may spread into Colorado hookless cactus AUs where there are large infestations of cheatgrass (*Bromus tectorum*) (NatureServe 2017). In the summer of 2020, this was demonstrated by the Pine Gulch Fire near DeBeque, CO, which burned north of habitat for *S. glaucus* but south and west of habitat for *S. dawsonii*.

2.6 CURRENT RANGE

Colorado hookless cactus is limited to western Colorado, specifically the Colorado and Gunnison River basins and their tributary canyons in Garfield, Mesa, Montrose, and Delta counties. *S. glaucus* occupies the Grand Valley and extends south through the high desert at the foot of the Grand Mesa along the alluvial terraces of the Gunnison River and the Dominguez and Escalante Creek drainages to near Montrose. *S. dawsonii* occupies colluvial slopes along the Colorado River from DeBeque downstream toward the Grand Valley and along the Roan and Plateau Creek drainages (McGlaughlin and Naibauer 2021, p. 2).

Based on the AU boundaries we delineated for this SSA report, the range of *S. glaucus* is approximately 1535 km^2 (593 sq mi) and covers a continuous area in the three alluvial terraces of the eastern half of the Grand Valley near Grand Junction south to Gunnison River near Delta. We also estimate that the range of (*S. dawsonii*) is approximately 456 km^2 (176 sq mi) and is distributed along the drainages of the Colorado River near DeBeque.

Figure 5. Range of Colorado hookless cactus (Heil and Porter 2004).

2.7 GENETIC DIVERSITY

In the most recent genetic analysis, fine-scale genetic patterns were examined by using Random Site-Associated DNA sequencing (RADseq) within *S. glaucus* and three closely related species (McGlaughlin and Naibauer 2021, p. 2). In this study of *Sclerocactus* in Colorado, genetic diversity was found to be low to moderate, with limited evidence of inbreeding (McGlaughlin and Naibauer 2021, p. 22). *S. glaucus* demonstrates sufficient connectivity, which results in ongoing and recent genetic exchange and forms a genetically cohesive group (McGlaughlin and Naibauer 2021, p. 2). *S. dawsonii* is genetically isolated and diverged from *S. glaucus* and all genetic analyses support *S. dawsonii* is a distinct entity (McGlaughlin and Naibauer 2021, p. 2). Recent population bottlenecks do not appear to be a concern, based on the relative consistency of levels of genetic diversity found in recent studies (McGlaughlin and Naibauer 2021, p. 22).

CHAPTER 3: SPECIES NEEDS

3.1 INDIVIDUAL LEVEL NEEDS

In Table 3, we summarize the resources and conditions necessary for both Colorado hookless cactus species to persist at an individual level in each life stage.

Table 3. Colorado hookless cactus resource needs and resource functions by life stage.

Life Stage	Resource Needs	Resource Function
Seeds	Shallow exposed sandy or shale soils of sedimentary parent material or gravelly deposits of river alluvium	Habitat & Nutrition
	Semi-arid, high elevation desert climate (1,200-2,000 m) with 8-12 inches rain/year	
	Cold Stratification (deep cold)	Reproduction
Seedlings	Shallow exposed sandy or shale soils of sedimentary parent material or gravelly deposits of river alluvium	Habitat & Nutrition
	Semi-arid, high elevation desert climate (1,200-2,000 m) with 8-12 inches rain/year	
Mature/Reproductive Adults	Shallow exposed sandy or shale soils of sedimentary parent material or gravelly deposits of river alluvium	Habitat & Nutrition
	Semi-arid, high elevation desert climate (1,200 to 2,000 m) with 8-12 inches rain/year	
	Ants & gravity for seed dispersal mechanism	Reproduction
	Pollinators	

Habitat Structure and Soils– Both species of Colorado hookless cactus are distributed throughout their range with some generality relative to dominant plant community, soil condition, and exposure. Both species of Colorado hookless cactus are found more frequently where soils are developed, intact, and cryptogrammic, in sheltered microhabitats within the canopy of dwarf shrubs and bunchgrass "nurse plants" (BLM 2020, p. 18). Features such as these might be indicative of areas that have received less pressure from disturbance. Despite its tendency to favor these soils, it appears to disperse in some generality in terms of the makeup and quality of the substrate on which it is found to occur (BLM 2020, p.18).

Soil Moisture – Although highly xerophytic, *S. glaucus* and *S. dawsonii* need precipitation or other water sources to fuel germination, growth, and reproduction. Regional climate of Colorado hookless cactus is consistent with the Colorado Plateau region, which is characterized by semi-arid, high elevation desert. Annual precipitation ranges between 8-12 inches annually, averaging of 8.67 inches between 1900 and 2016, recorded at the Grand Junction weather station (Western Regional Climate Center 2019).

Diverse and Abundant Pollinators – Pollinator assisted outcrossing (xenogamy) is the primary mode of genetic exchange for the Colorado hookless cactus (Janeba 2009, p. 67; Tepedino *et al*. 2010, p. 382). Like most species of cacti, pollinators are necessary for sexual reproduction and research has found that plants produced more seeds via outcrossing than selfing (Tepedino *et al*.

2010, p. 382). Some early observations of pollinators visiting Colorado hookless cactus revealed *Agapostemon texanus* (Halictidae) as the most frequent visitor (Rechel, Ballard& Novotny 1999, p. 144). Additional studies suggested that ground-nesting species of bees within the subfamily Halictinae are the most frequent flower visitors to Colorado hookless cactus (Janeba 2009, p. 63; Tepedino *et al*. 2010, p. 383).

Seed Dispersal Mechanism – Distribution of both species of Colorado hookless cactus is primarily limited by seed dispersal. A primary mechanism for short distance seed dispersal is small black ants, identified as *Monomorius minimum* (subfamily Myrmicinae) (BLM 2020, p. 16). Heavy summer rains provide flowing water to help disperse seeds into areas surrounding plants. Birds and small mammals feeding on the fruit and seeds may also contribute to dispersal of seeds (BLM 2020, p. 16).

Cold Stratification (deep cold) – The seeds of many plant species, including Colorado hookless cactus, have an embryonic dormancy phase and will not sprout until this dormancy is broken. This evolutionary adaptation ensures that germination only occurs during favorable environmental conditions. We are unsure of the precise mechanism that breaks dormancy of Colorado hookless cactus seeds, but it is possible that a period of deep cold during winter months contributes to germination the following spring (Rechel *et al*. 1999, p. 144; Riley and Riley 2018, p. 217).

3.2 Analytical Unit Level Ecology

To discern the nuances in conditions that occur across the ranges of the species and stressors that are influencing these conditions, we analyze the resiliency, redundancy, and representation of the Colorado hookless cactus in 10 representative analytical units (AUs). Boundaries for these AUs include all occupied habitat and are delineated by natural geological and ecological features as well as management boundaries. Within each AU are multiple clusters of cacti and all known plant occurrences are located within the boundaries of the 10 AUs. There are 8 AUs that represent *S. glaucus* and 2 AUs that represent *S. dawsonii.* Analytical Units were chosen for this analysis, rather than define populations for each species, to avoid confusion with past definitions of Colorado hookless cactus populations used in literature that predates the taxonomic split of *S. glaucus* and *S. dawsonii*.

To be resilient, Colorado hookless cactus AUs need a sufficient number of individuals with adequate levels of recruitment and survivorship, and pollinator connectivity between plants to facilitate reproduction and gene flow. These demographic and distribution factors are influenced by the availability of the resources needed by plants at the individual level (Table 3). To be resilient, Colorado hookless cactus plants within the defined AUs need sufficient recruitment to maintain survival and reproduction despite disturbance. In general, the more recruitment in an AU, the better able it is to sustain the AU over time and withstand stochastic events.

Survivorship – Colorado hookless cactus need sufficient survivorship at each life stage (seed, seedling, and mature reproductive adults) to maintain an AU with a functional distribution of individuals in each life stage and to withstand stochastic events. Monitoring efforts have been focused on understanding population trends of Colorado hookless cactus since the time of its

listing (BLM 2020, p. 21). Denver Botanic Gardens and Bureau of Land Management (BLM) have recorded demographic trend monitoring data at sites throughout the range of both Colorado hookless cactus species since 2007 (DePrenger-Levin and Hufft 2021, pg. 3-5.). Data from 18 long-term demographic monitoring plots maintained by the Denver Botanic Gardens and the BLM allow them to calculate overall survival rates for each species. For *S. glaucus*, the overall survival rate is 85 percent and for *S. dawsonii*, overall survival rate is 90 percent (DePrenger-Levin 2021a, pers. comm.). The survival rate for each species is derived from averaging the survival rates among the associated AUs.

Colorado hookless plants are considered a hardy, long-lived perennial species (i.e., high survival probabilities and low levels of recruitment) (BLM 2018, p. 15). High seedling survival was observed in a 2018 BLM monitoring study, an indication that there is a high probability of an individual persisting to reproductive stage once established (BLM 2018, p. 14). Results from the same BLM study found that plants would not flower until they reached a diameter of >4cm. (BLM 2018, p.14). Plants are likely at least 4 to 6 years old before they become reproductive and continue to flower throughout their relatively long life (DePrenger-Levin 2021c, pers. comm.).

Analytical Unit Size – In order to withstand stochastic events, both Colorado hookless cactus species need a sufficient number of individual plants in each AU. According to a 2018 BLM monitoring study, Colorado hookless cactus core population areas typically occur over a quarter acre area and on average consist of a couple hundred individual plants (BLM 2018, p. 15). Previous estimates from the Colorado Natural Heritage Program (CNHP) were approximately 16,800 plants for *S. glaucus* and between 19,000 and 22,000 plants for the total range-wide number of individuals in both species *(S. glaucus and S. dawsonii)* based on observations within element occurrence records (CNHP 2017, entire).

However, we now know that there are many more plants than previously reported. In a recent paper from the BLM, a novel sampling-based procedure was used to estimate the minimum population size of *S. glaucus*. By using plant density estimates derived from sampled macroplots and extrapolating them to known habitat areas, an estimation of the minimum population size for the entire area of occupation of the taxon can be determined. Through this exercise, population size estimates for the species are much higher than previous estimates (Krening *et al*. 2021, p. 10).

Using this sampling-based procedure to determine the minimum AU size (90 percent lower confidence level (LCL)), we can estimate the *S. glaucus* minimum AU size at 68,120 plants and the *S. dawsonii* minimum AU size at 21,058 plants (Table 4).

Table 4. Estimated number of individuals in each analytical unit of S. glaucus and S. dawsonii.

	Minimum Population Estimate	90% LCL	90% UCL
S. glaucus			
Cactus Park	19,558	12,924	26,192
Devil's Thumb	13,294	8,785	17,803
Dominguez-Escalante	18,432	12,180	24,684
Gunnison Gorge	3,440	2,273	4,607
Gunnison River East	16,923	11,183	22,663
North Fruita Desert	8,162	5,393	10,930
Palisade	232	153	311
Whitewater	23,047	15,229	30,864
Total Estimate	***103,086***	***68,120***	***138,053***
S. dawsonii			
Plateau Creek*	3,632	2,400	4,863
Roan Creek*	28,235	18,658	37,812
Total Estimate*	***31,867***	***21,058***	***42,675***

*Estimates derived from sampling from *S. glaucus* populations

Connectivity – Connectivity between AUs is important for gene flow, population rescue, and for the species' resilience to stochastic events. Pollinators help mediate connectivity within and between AUs. A resilient AU of both species of Colorado hookless cactus would have survivorship at rates that are able to sustain AUs with pollinator connectivity between individuals and clusters of plants within the AU. Studies conducted measuring genetic distance (Fst) and estimating the number of migrants per generation (N_m), support that there is gene flow (i.e., connectivity) among *S. glaucus* populations within AUs (Dawson 2021, pers. comm.).

Recruitment – The more recruitment within an AU, the more able the AU is to withstand stochastic events. As discussed above, Colorado hookless plants are considered a hardy, long-lived perennial species, which typically means they may have naturally low levels of recruitment (BLM 2018, p. 8). In a report detailing the results of a demographic monitoring study from 2011-2018, the BLM found that recruitment rates were indeed relatively low ($\mu = 0.57$) and also varied across years and sites, ranging from 0.03 to 2.83 but rarely exceeding 1 recruit for every flowering plant from the previous year (BLM 2018, p. 8). Low recruitment rate is the main feature of why Colorado hookless cactus is considered a rare species. A long-lived species with high levels of recruitment would have a rapidly growing population size and no longer be considered "rare" (Krening 2021b, pers. comm.).

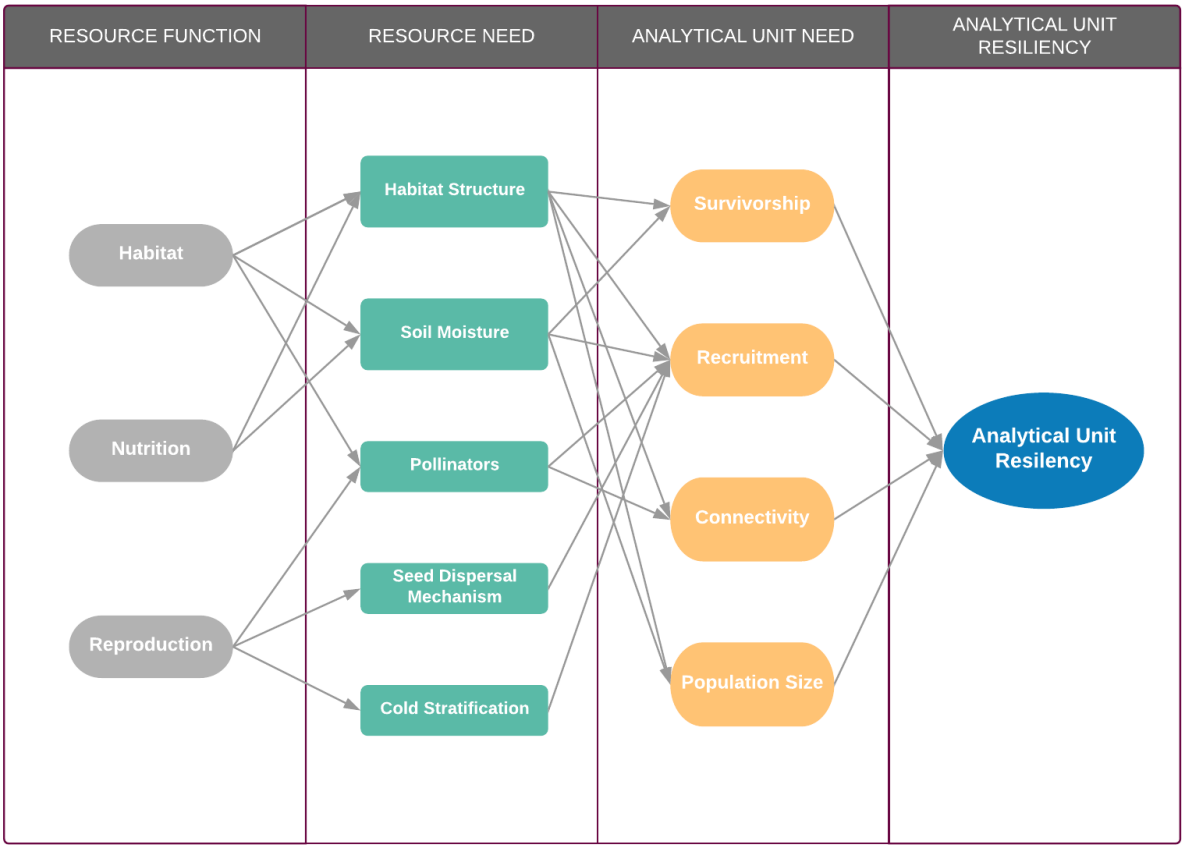

Figure 6. Diagram of interrelated influences of resource needs and resource functions on demographic and distribution factors and overall analytical unit resiliency.

3.3 Species Level Ecology *(S. glaucus and S. dawsonii)*

At the species-level scale, both Colorado hookless cactus species require (1) a sufficient number and distribution of AUs to withstand catastrophic events (redundancy) and (2) a range of variation that allows the species to adapt to changing environmental conditions (representation).

We evaluate the redundancy of each species by the number and distribution of Colorado hookless cactus plants within the AUs. Having multiple AUs distributed across a larger area spreads the risk of catastrophic events that may affect one or more units simultaneously, thereby affecting the whole species. A higher number of AUs distributed broadly across the species' ranges reduces catastrophic risk to the species and provides for redundancy. Fewer AUs distributed narrowly across their ranges would increase catastrophic risk and lower redundancy.

Representation of both species of Colorado hookless cactus is based on the presence of multiple, self-sustaining AUs across the ranges of each species, and their contributions to providing adaptive capacity to the species in the face of changing conditions. Both species of Colorado hookless cactus need to maintain some level of genetic variability of plant populations within and between AUs to adapt to changing environmental conditions caused by climate change and other factors. For both species, there is more ecological and morphological variability within the

species' ranges than most narrow endemic plants (Dawson 2021, pers. comm.; Krening 2021b, pers. comm.).

3.4 SUMMARY

To summarize the individual, AUs, and species needs to maintain viability, *S. glaucus* and *S. dawsonii* both need multiple, resilient AUs distributed across their ranges to reduce risk associated with catastrophes (redundancy) and long-term environmental change (representation). The species' resource needs must be of the quantity and quality necessary to support resilient AUs that can withstand stochastic change. Resource needs of the species include semi-arid, high elevation desert climate (elevation of 1200-2000 m) with 8-12 inches rain/year, shallow exposed sandy or shaley soils of sedimentary parent material or gravelly deposits of river alluvium, pollinators, and a period of dormancy (deep cold). A resilient AU of both species of Colorado hookless cactus would have survivorship at rates that are able to sustain AUs with pollinator connectivity between individuals and clusters of plants within the AU. Resilient AUs also contain enough individuals across each life stage (seed, seedling, and mature reproductive adult) to bounce back after experiencing environmental stressors such as intermediate disturbance, occasional drought, or grazing. Colorado hookless cactus redundancy is influenced by the number of AUs across the landscape. More AUs across the range of Colorado hookless cactus increase the species' ability to withstand catastrophic events. Individuals and AUs inhabiting diverse ecological settings and exhibiting genetic or phenological variation add to the level of representation across the species' range. The greater diversity observed in Colorado hookless cactus genetics, habitats, and morphology, the more likely it is to be able to adapt to change over time.

CHAPTER 4: CURRENT CONDITIONS

4.1 STRESSORS ON THE SURVIVAL OF THE SPECIES

At the time of listing, the Service identified the potential development of oil shale deposits and gold mining, off-road vehicle use, collecting pressure, livestock grazing, and an inadequacy of existing regulatory mechanisms as threats to the existence of the species (44 FR 58868, October 11, 1979). Much more is presently known about the species' stressors than at the time of listing. Several of the stressors identified in the original listing decision, including oil shale and tar sands development, are no longer relevant (BLM 2020, p. 30). Recent genetic studies have aided in our understanding of the species and eliminated any immediate concern of hybridization with other *Sclerocactus* species (Schwabe *et al*. 2015, p. 443). Currently, stressors that could influence the Colorado hookless cactus include livestock use, invasive species, oil and gas development, off-highway vehicle (OHV) recreational use, predation, development and maintenance of utility corridors, the effects of global climate change, herbicide and pesticide application, and collection and commercial trade (BLM 2020, p.30).

Table 5. Current stressors to Colorado hookless cactus (continued on next page).

SOURCE(S)	Activity(ies)	Stressor(s)	Affected Resource(s)	Response to Stressor(s)	
				Individual	Analytical Unit
Livestock Use	Livestock (sheep, cattle, horses, etc.) grazing, trailing, bedding	Mechanical damage to individual plants from livestock trampling and crushing. Larger cacti are more susceptible to uprooting and crushing by livestock hooves. Compaction of soil. Loss of individual plants.	Direct effect to plants; soil, loss of site value with changes in vegetation structure (reduction in cover opening habitat and introduction of invasive species).	Mortality to plants	Loss of larger, reproductive individuals can cause a demographic stressor to plants within AUs. Intense sheep grazing & bedding can result in extirpation of occurrences.
Invasive Species	Activities that can lead to introduction of invasive species: livestock grazing & trailing; OHV and other recreational activities; oil & gas related activities; utility corridors, etc.	Disturbed sites are susceptible to invasive species, which compete for resources with cacti. Degradation of soil productivity, water quality and quantity.	Soil & water	Mortality to plants	Degradation of available habitat, competition with invasive plant species.
Oil & Gas Development	Oil and gas exploration, development, and production, including infrastructure	Modification, curtailment, and destruction in habitat.	Loss of plants, soil seed banks and pollinator habitat	Mortality to plants, degradation of habitat quality	May cause extirpation of occurrence, loss of dispersal and colonization of unoccupied habitats.
OHV Recreational Use	Off Highway Vehicles traveling cross country & staging of transport vehicles (trailers).	Plants are crushed, soil is compacted due to repeated use by OHV's, increased erosion & sedimentation, increase in dust.	Direct effect to plants, soils	Mortality to plants, loss of quality of habitat	Habitat fragmentation, limiting reproductive success
Predation	Small mammal herbivory, parasitism by Opuntia-borer beetle *(Moneilema semipunctuatum)*	Herbivory causes partial or complete consumption of stems of cactus individuals.	Direct effect to individuals.	Mortality to plants & loss of reproductive function due to herbivory.	Alteration of age structure due to predation on mature reproductive plants.
Utility Corridors	Installation and maintenance of utility corridor Right of Way's, relocation of affected plants	Damage or loss of plants, fragmentation of habitat, increase in invasive species	Direct effect to individuals, competition with invasive species.	Mortality to plants	Degradation of available habitat, competition for resources with invasive plant species.

Climate Change	Predicted average global increase in temperature	Temperature (freeze/thaw cycle), water availability	Direct effect to plants, soils	Survival and fecundity of plants.	Change in vegetation composition, structure, species abundance, shift in range.
Herbicide & Pesticide Application	Application of herbicide and pesticide for invasive species	Mortality of plants	Direct effect to plants.	Mortality to plants	May cause extirpation of occurrence.
Collection & Commercial Trade	Unregulated, illegal collection and trade of wild plants and seeds	Loss of plants & seeds to collectors	Genetic integrity of plants species.	Removal of plants	Impacts to size of occurrence and genetic diversity

Although predation and herbicide and pesticide application have the potential to influence Colorado hookless cactus, these stressors are only known to impact individual plants. Illegal collection and commercial trade have proven to be less of a concern than originally suggested in the species' listing rule. Based on the professional judgement of species experts, these stressors do not present species or AU-level effects. Therefore, we do not carry predation, herbicide and pesticide application, or collection and commercial trade forward in our SSA analyses of current and future conditions. Additionally, currently, livestock use, invasive species, oil and gas development, OHV recreational use, and development and maintenance of utility corridors are only currently affecting individual plants, though these effects could increase in the future if the prevalence of the stressors increase or mitigation measures decrease. Climate change is not currently having AU-level or species-level effects and multiple studies indicate the species has low vulnerability to climate change (Treher et al. 2012, p. 52; Still et al. 2015, p. 116), though one study indicated a higher potential for effects (CNHP 2015, p. 533). Given the potential for future increases in effects, we carry forward livestock use, invasive species, oil and gas development, OHV recreational use, development and maintenance of utility corridors, and the effects of global climate change in our SSA analyses.

Hybridization with other *Sclerocactus* species in Colorado was not found to be recent or ongoing, thus not a conservation concern for *S. dawsonii* or *S. glaucus* and was not brought forward in our analyses of current and future conditions (McGlaughlin and Naibauer 2021, p. 22).

4.2 Conservation Efforts

Multiple agencies, volunteers, and community members are committed to the conservation and preservation of Colorado hookless cactus. Land ownership and management across the Colorado hookless cactus range are comprised of varying land ownership and management. The BLM owns and manages approximately 72 percent and 68 percent, respectively, of the land that comprises *S. glaucus* and *S. dawsonii* AUs. The BLM has implemented measures in planning documents to minimize and avoid impacts to Colorado hookless cactus and its habitat and contribute to its conservation and recovery. The majority of the remaining habitat is privately owned; less than 1 percent is owned by State or local governments.

Additionally, approximately 30 percent of the land in *S. glaucus* AUs and 41 percent of the land in *S. dawsonii* AUs have special BLM land management designations in the form of NCAs, ACECs, and a Wilderness Area (Table 7) (BLM 2020, p. 26). These designations limit or exclude the authorization of certain land uses, and some designations were specifically created for the conservation of natural resources. These lands help to facilitate the maintenance and recovery of cactus occurrences since they are areas where Colorado hookless cactus occurrences are not likely to be disturbed or adversely altered by land-use actions (BLM 2020, p. 26).

The range of the Colorado hookless cactus spans three separate BLM field offices (Colorado River Valley Field Office, Grand Junction Field Office, Uncompahgre Field Office) and two National Conservation Areas (NCAs) (Dominguez-Escalante and Gunnison Gorge). Each field office has their own set of planning documents that provide guidance for the management of lands under their purview. These documents contain slightly different language concerning the management of the habitat of listed species, but all seek to limit adverse impacts of land use to listed species including the Colorado hookless cactus (BLM 2020, p. 26).

The most important is the 210,172-acre Dominguez Escalante National Conservation Area, which overlaps a large portion of the Colorado hookless cactus range and contains a significant amount of suitable and occupied habitat (BLM 2020, p. 26). This NCA provides for the long-term conservation and protection of the Colorado hookless cactus. Areas of Critical Environmental Concern (ACEC) and Wilderness Study Areas (WSA) possess special management status where surface use is excluded or limited. These areas and their protection are summarized in the following table:

Table 6. BLM areas with special management status located in Colorado hookless cactus analytical units.

Name	Year Designated	Acres	Protections	Analytical Unit
Dominguez-Escalante NCA	2009	210,172 acres	It was created by the 2009 Omnibus Public Lands Management Act and is managed as part of the Bureau of Land Management's National Conservation Lands; miles of routes were closed to motorized and mechanized travel.	Dominguez - Escalante AU, Gunnison River East AU and Cactus Park AU
Dominguez Canyon Wilderness	2009	66,280 acres	Located within the Dominguez-Escalante NCA; applies protections under the Wilderness Act of 1964.	Dominguez - Escalante AU
Gibbler Mountain ACEC	2017	1266 acres	Located within the Dominguez-Escalante NCA, travel routes reduced within 200 meters of sensitive plants, surface disturbing activities that pose stressors to Colorado hookless cactus prohibited, managed as a Right-Of-Way (ROW) exclusion area.	Dominguez - Escalante AU

River Rims ACEC	2017	5,314 acres	Located within the Dominguez-Escalante NCA, ROW exclusion area, travel routes reduced within 200 meters of sensitive plants, surface disturbing activities prohibited, livestock activities managed to protect sensitive plants, limits to Special Recreation Permits (SRPs).	Cactus Park AU and Gunnison River East AU
Escalante Canyon ACEC	1989	2,282 acres	Located within the Dominguez-Escalante NCA, livestock activities managed to protect sensitive plants, ROW exclusion area, limits to Special Recreation Permits (SRPs), woodland harvest prohibited, camping limited to designated and developed areas.	Dominguez - Escalante AU
Gunnison Gorge National Conservation Area	1999 (expanded boundaries in 2003)	52,728 acres	Area is concurrent with the southeast extension of the Colorado hookless cactus' range, planning documents specify a focus on protecting special status species.	Gunnison Gorge AU
Adobe Badlands ACEC	1989	6,381 acres	Surface disturbing activities and occupancy prohibited; livestock forage utilization limited.	Devil's Thumb AU
Pyramid Rock ACEC	1987	1,257 acres	Considered a "core conservation population area" to preserve Colorado hookless cactus and possesses the highest level of protection against land-use impacts: No motorized travel (including over snow), no target shooting, no SRPs, no camping, no livestock grazing, includes a ROW exclusion area; Surface occupancy and surface disturbing activities prohibited (NSO).	Roan Creek AU
South Shale Ridge ACEC	2015	27,838 acres	ROW exclusion area, motorized and mechanized travel limited to designated routes, No SRPs and NSO.	Roan Creek AU
Atwell Gulch ACEC	2015	2,859 acres	NSO, no motorized travel (including over snow), No SRPs, Livestock and ROWs excluded on 2,600 acres, 260 acres managed as a ROW avoidance area.	Plateau Creek AU

Mount Logan Foothills ACEC	2015	3,969 acres	NSO, No SRPs, ROW avoidance area, travel limited to designated routes, closed to leasing of non-energy materials and salable minerals/mineral material disposal, closed to commercial timber harvest, firewood cutting, and special forest product harvest.	Roan Creek AU
Indian Creek ACEC	2015	2,345 acres	ROW exclusion area, motorized and mechanized travel limited to designated routes, surface occupancy and surface disturbing activities prohibited (NSO).	Whitewater AU
Rough Canyon ACEC	1987	2,800 acres	Travel limited to designated routes (2,200) or closed to motorized and mechanized travel (600 acres), ROW exclusion area, closed to fluid mineral leasing and geophysical exploration, and NSO	Dominguez - Escalante AU
Mount Garfield ACEC	2015	2,400 acres	ROW exclusion area, closed to motorized travel (including over-snow travel), target shooting prohibited, prohibits surface occupancy and surface disturbing activities.	North Fruita Desert AU and Palisade AU

Table 7. Acres of BLM ownership and acres with special management designations within each Analytical Unit.

Analytical Unit	Total Acres	BLM Acres	Acres With BLM Special Designations
Sclerocactus glaucus			
Cactus Park	28,702	22,615	6,923
Devil's Thumb	65,632	45,548	26,462
Dominguez-Escalante	84,592	79,062	61,541
Gunnison Gorge	30,829	14,856	2,146
Gunnison River East	37,570	25,835	3,139
North Fruita Desert	49,721	42,721	2,291
Palisade	9,269	4,566	4,267
Whitewater	73,033	39,524	5,836
***S. glaucus* Total**	**379,348**	**274,727**	**112,605**
Sclerocactus dawsonii			
Plateau Creek	47,849	23,659	17,836
Roan Creek	64,874	52,708	27,917
***S. dawsonii* Total**	**112,723**	**76,367**	**45,753**

4.3 CURRENT STATUS AND VIABILITY

In this section, we analyze the current status of Colorado hookless cactus in terms of resiliency, redundancy, and representation. Table 8 outlines our understanding of what constitutes a resilient AU of Colorado hookless cactus in relation to the resource needs of the species. We used the following metrics and thresholds to evaluate the current and future availability of a subset of the resource needs we discussed in Chapter 3 (Table 8); this subset includes the needs for which we had data available to consistently measure these needs across AUs:

Habitat Condition Index: To assess the current and future condition of the Colorado hookless cactus, BLM experts developed a "Habitat Condition Index" (HCI) (see Appendix 1). The HCI produces a single habitat condition score from the aggregated rankings of three biologically relevant condition categories: habitat quality, habitat size and habitat type. The result of the HCI is a habitat condition score (high, moderate, and low) for each AU (Holsinger and Krening 2021, p. 2).

Habitat quality was determined using BLM AIM (Assessment, Inventory, and Monitoring) and LMF (Landscape Management Framework) data. A total of 134 individual AIM/LMF sample points fall within the AUs and were used for the analysis. Three separate indicators were used to evaluate habitat quality: invasive species cover, bare ground, and native perennial cover. Habitat type was determined using the output from the predictive model for Colorado hookless cactus (Holsinger and Krening 2021, p. 5). By employing several bioclimatic and geographic variables in GIS, this model predicted habitat suitability across the species range. Habitat size was determined by the proportion of each AU's modeled cactus habitat (combined total of high and moderate suitability habitat, per the model) relative to the total area of all AUs (Holsinger and Krening 2021, p. 4).

The Habitat Condition Index was applied to each of the 10 AUs (see Appendix 1). The average score for *S. dawsonii* is 1.53 and the average score for *S. glaucus* is 1.54, indicating a high Habitat Condition Score throughout both species' ranges.

Water Deficit: To assess climate conditions, we used historic data downscaled to the ranges of *S. glaucus* and *S. dawsonii* in western Colorado from 1979-2020, obtained from the North Central Climate Adaptation Science Center, the Cooperative Institute for Research in Environmental Sciences, and the Climate Toolbox (Hegewisch 2020; North Central 2021, p. 1). Using the data from 1979–2000, we calculated the baseline climate conditions in the ranges of the species, then compared current climate conditions (2011-2020) to this baseline.

It is normal for climate variables to fluctuate annually to some extent. Because of this, *S. glaucus* and *S. dawsonii* have experienced a range of conditions in the past and have proven to be able to withstand fluctuations within this range. However, changes in climate outside the range of normal variation over time may affect the species.

S. glaucus and *S. dawsonii* need precipitation for germination, growth, and reproduction. In our assessment of current conditions, we use summer (June, July, and August) water deficit to describe the availability of water for the species. Water deficit is a proxy for drought and soil

moisture and combines multiple climatic variables to represent the supply of water (precipitation) in relation to the demand for water (potential evapotranspiration). For a given area, water deficit equals potential evapotranspiration minus precipitation. We expect that changes in water availability could have an impact on *S. glaucus* and *S. dawsonii*. Thresholds used to describe High, Moderate, and Low resiliency conditions are based on deviation from the historic average and calibrated using species expert knowledge of historically "bad" years in which the species were negatively impacted by drought (Table 8). We saw that even in recent 'bad' years reproductive rates didn't suffer, maybe some increase in mortality but minimal (DePrenger-Levin 2021c, pers. comm.) Although the species have experienced short-term fluctuations beyond one or two standard deviations from the historic average in the past, we expect extended periods of drought to have greater long-term effects on the species.

Survivorship: Colorado hookless cactus need sufficient survivorship at each life stage (seed, seedling, vegetative, and mature reproductive adults) to maintain an AU with a functional distribution of individuals in each life stage and to withstand stochastic events. Monitoring efforts have been focused on understanding population trends of Colorado hookless cactus since the time of its listing (BLM 2020, p. 21). Denver Botanic Gardens and Bureau of Land Management (BLM) have recorded demographic trend monitoring data at sites throughout the range of both Colorado hookless cactus species since 2007 (DePrenger-Levin and Hufft 2021, pg. 5-7). Calculations from these long-term demographic monitoring plots maintained by the Denver Botanic Gardens and the BLM allow them to calculate overall survival rates from year to year for each species. The single survival rate value for each species is derived from averaging the survival rates among the associated AUs.

Minimum Population Size Estimate (90% LCL): In order to withstand stochastic events, both Colorado hookless cactus species need a sufficient number of individual plants in each AU. In order to assess the number of individuals in each AU in our categorical model, we used the 90 percent LCL values from BLM's novel sampling-based procedure (see Section 3.2 above) (Krening *et al*. 2021, p. 10). By using the 90 percent lower confidence limit (LCL) for AU estimates in our analysis, rather than the 90 percent upper confidence level, we can ensure a conservative estimate and avoid biases that could result in overstating the total number of plants.

Analytical Unit Resiliency: To calculate the overall resiliency of each AU, we took an average of the habitat condition index, survivorship, minimum population size estimates, and water deficit scores, and assigned thresholds that evenly divided the range of the highest and lowest possible scores.

We categorized overall resiliency of each AU as high, moderate, or low, based on the ratings in each of the below categories (Table 8). We base these assumptions on current and historic demographic and environmental data and represent the best available information we have about the condition of *S. dawsonii* and *S. glaucus*.

Table 8. Conditions Category Table: the demographic, distribution, and habitat factors used to categorize the health of Colorado hookless cactus.

Analytical Unit Resiliency	Habitat Needs	Demographic/Distribution Factors		Climate	Analytical Unit Resiliency Score
	Habitat Condition Index	Survivorship	Minimum Population Size Estimates (90% LCL)	Summer Water Deficit	
High (Healthy)	1.41 – 1.8	80% - 100%	> 10,000 Plants / AU	within 1 standard deviation of historic mean	2.34 - 3
Moderate	1.01 – 1.4	50% -80%	500-10,000 Plants / AU	within 2 standard deviations of historic mean	1.67 – 2.33
Low	0.6 – 1.00	0-50%	< 500 Plants / AU	2+ standard deviations of historic mean	1 – 1.66

Other considerations:

Climate: We explored the idea of using a second climate metric in our Condition Category Table (Table 7) to highlight the importance of seasonal timing: an interaction of the length of the growing season and the date of last frost in the spring. If the growing season starts earlier in the year and cacti begin growing flowers, a late spring frost could harm or kill flower buds, thereby negatively impacting reproductive success. However, we are not aware of this phenomenon having long-term negative effects to the species to date. Researchers have observed flower bud kill due to late spring frosts, but the plants generally produce another set of buds after the frost that appear to be successful in developing into fruit (DePrenger-Levin 2021b, pers. comm.). In addition, we are unsure of the seasonal trigger that initiates flower production for the species. If the species are triggered by daylight hours rather than temperature, buds will not begin growing earlier in the season, even if temperatures warm, and will not be at heightened risk of being damaged by a late spring frost. Moreover, in years without a harmful late frost, a longer growing season would have positive effects on the species. Because it is not clear that this seasonal timing metric would have AU- or species-level impacts, or if these impacts would be positive or negative, we did not carry it forward in our analysis of current or future condition.

Pollinators: Studies found that ground-nesting species of bees within the subfamily Halictinae are the most frequent flower visitors to Colorado hookless cactus (Janeba 2009, p. 63; Tepedino *et al*. 2010, p. 383). However, pollination is likely carried out by a variety of native bees and other insects, including ants and beetles (Service 1990, p. 3). Since Colorado hookless cactus

have not been found to require a specialist pollinator, abundance of pollinators is likely not an issue and was not brought forward in our analysis of current or future condition.

Genetic diversity and connectivity: Levels of genetic diversity are low to moderate with limited differences among AUs and generally uniform across all AUs of *S. glaucus* and all AUs of *S. dawsonii* (McGlaughlin and Naibauer 2021, p. 15). *S. glaucus* demonstrates sufficient connectivity, which results in ongoing and recent genetic exchange. *S. dawsonii* is genetically isolated and diverged from *S. glaucus* (McGlaughlin and Naibauer 2021, p. 22). Because no major differences were observed among AUs and genetic diversity and inbreeding does not appear to be a concern for either species in the foreseeable future (McGlaughlin and Naibauer 2021, p. 22), we did not use this metric in our Condition Category Table, though we do recognize genetic diversity as a factor in assessing representation for both species.

4.4 CURRENT CONDITION OF *S. DAWSONII*

S. dawsonii straddles Garfield and Mesa Counties. This species is comprised of two AUs, Roan Creek and Plateau Creek. The AUs are divided by the Colorado River and I-70, with the Roan Creek AU situated to the Northwest of the town of DeBeque and Plateau Creek AU is situated to the Southeast of DeBeque. Most of the occurrences of *S. dawsonii* lie within the Roan Creek AU. The total minimum estimate of *S. dawsonii* individuals is 31,867 plants (Holsinger and Krening 2021, p. 10). Table 9 outlines the size and estimated minimum population sizes for each *S. dawsonii* AU.

Table 9. S. dawsonii estimated minimum number of plants in each analytical unit.

Analytical Unit	Estimated Minimum AU (# of plants)
*Plateau Creek	3,632
*Roan Creek	28,235
Total	31,867

*Estimates derived from sampling from *S. glaucus* analytical units.

When measured against the metrics outlined in Table 7, both *S. dawsonii* AUs rank high in overall resiliency (Table 10). This is due to the high estimated number of individuals in each AU, high levels of survivorship, high and moderate availability of habitat features that support the cactus, and a current summer water deficit that is similar to the historic average. The stressors operating in the Plateau Creek AU and the Roan Creek AU are comparable, but the Plateau Creek AU is geographically smaller, which partly influences its lower rating for the population size category (A. Lincoln 2021, pers. comm.).

Table 10. Measure of current resiliency of S. dawsonii based on current demographic, distribution, and habitat conditions in the two analytical units of the species. A green shading indicates a high score, yellow indicates moderate, and red indicates low.

Analytical Unit		Habitat Needs	Demographic / Distribution Factors		Climate	Analytical Unit Resiliency
		Habitat Condition Index	Species-level Survival	Minimum Population Size (90% LCL)	Summer Water Deficit	
S. dawsonii	Plateau Creek	Moderate (1.40)	High (90%)	Moderate (2,400)	High	High
	Roan Creek	High (1.67)		High (18,658)	High	High

4.5 CURRENT CONDITION OF *S. GLAUCUS*

S. glaucus is comprised of eight AUs, which are in Mesa, Delta, and Montrose Counties. Table 11 outlines the size and estimated minimum AU (number of plants) sizes for each *S. glaucus* AU.

Table 11. S. glaucus estimated minimum number of plants in each analytical unit.

Analytical Unit	Estimated Minimum AU (# of plants)
Cactus Park	19,558
Devil's Thumb	13,294
Dominguez-Escalante	18,432
Gunnison Gorge	3,440
Gunnison River East	16,923
North Fruita Desert	8,162
Palisade	232
Whitewater	23,047
Total	103,086

When measured against the metrics outlined in Table 7, all but one of the *S. glaucus* AUs have an overall score of high resiliency (Table 12). This is due to the large estimated number of individuals in each AU, high levels of survivorship, adequate habitat resources, and a current summer water deficit (averaged over the past decade) that is similar to the historic average. The only AU that does not have an overall high rating is the Palisade AU, which has moderate resiliency overall due to its extremely small population size and moderate score for the habitat index. This AU is considerably smaller in area than the other AUs. A major highway (U.S. Interstate 70) and the Colorado River cut through this AU, fragmenting the habitat. Additionally, a high proportion of this AU is private and State land, which contain forms of

development (e.g., truck stop, shooting range, power plant) that present additional stressors to the species and its habitat (Lincoln 2021, pers. comm.).

Table 12. Measure of current resiliency of S. glaucus based on current demographic, distribution, and habitat conditions in the eight analytical units of the species. A green shading indicates a high score, yellow indicates moderate, and red indicates low.

Analytical Unit		Habitat Needs	Demographic / Distribution Factors		Climate	Analytical Unit Resiliency
		Habitat Condition Index	Species-level Survival	Minimum Population Size (90% LCL)	Summer Water Deficit	
S. glaucus	Whitewater	High (1.60)	High (85.00%)	High (15,229)	High	High
	Palisade	Moderate (1.20)		Low (153)	High	Moderate
	Dominguez-Escalante	High (1.80)		High (12,180)	High	High
	North Fruita Desert	Moderate (1.20)		Moderate (5,393)	High	High
	Devil's Thumb	High (1.80)		Moderate (8,785)	High	High
	Cactus Park	High (1.60)		High (12,924)	High	High
	Gunnison Gorge	Moderate (1.27)		Moderate (2,273)	High	High
	Gunnison River East	High (1.80)		High (11,183)	High	High

4.6 Summary of Current Condition

All but one of the AUs of both species of Colorado hookless cactus has high resiliency. Inventory and monitoring efforts led by the BLM and Denver Botanic Gardens have led us to the understanding that both species of the hookless cactus in Colorado are much more abundant than estimated at the time of listing. At the time of listing, it was thought the species consisted of approximately 15,000 individual plant found at eight sites in Colorado and Utah (44 FR 58868, October 11, 1979). Currently, we have estimated the minimum population size to be closer to 103,086 plants for *S. glaucus* and 31,867 plants for *S. dawsonii* (Holsinger and Krening 2021, p. 10).

Range-wide monitoring efforts have demonstrated a stable trend over recent years and have also provided a detailed understanding of demographic features and population dynamics. Across their limited ranges, both species of Colorado hookless cactus are relatively abundant, which contribute to the high levels of resiliency in all but one AU. Redundancy for narrow endemic species is inherently limited; however, *S. glaucus* plants are distributed broadly across the range of the species in eight AUs, providing redundancy throughout its relatively small geographic range. With only two AUs, redundancy of *S. dawsonii* is limited. However, the plausibility of catastrophic events also influences species' redundancy; if catastrophic events are unlikely within the range of the species, catastrophic risk is inherently lower. We are unaware of any plausible activity or naturally occurring event that would constitute a catastrophic event for

either species. For example, fire is not a common occurrence in *S. glaucus* or *S. dawsonii* habitat as this habitat lacks the fuels to sustain a burn, though increased invasive species presence could elevate this risk (Service 2021, p. 28). Additionally, the range of both species contain natural and manmade barriers (i.e., rivers, canyons, highways) that would prevent the spread of any catastrophic fire throughout the entire range of the species. Redundancy for narrow endemic species is intrinsically limited; however, *S. glaucus* plants are distributed broadly across the range of the species in eight AUs, providing redundancy throughout its relatively small geographic range. With only two AUs, redundancy of *S. dawsonii* is limited; however, as a narrowly endemic plant, it has likely always had a small range and limited redundancy. Additionally, given the lack of plausible catastrophic events across the range of both species, even the narrow range of *S. dawsonii* does not introduce appreciable catastrophic risk.

Both species exhibit some ecological and morphological variability, coupled with low to moderate genetic diversity among AUs (McGlaughlin and Naibauer 2021, p. 22). Inbreeding is not an immediate concern for either species (McGlaughlin and Naibauer 2021, p. 22). Additionally, *S. glaucus* demonstrates sufficient connectivity, which results in ongoing and recent genetic exchange (McGlaughlin and Naibauer 2021, p. 2). *S. dawsonii* is genetically isolated and diverged from *S. glaucus*; all genetic analyses support that *S. dawsonii* is a distinct entity (McGlaughlin and Naibauer 2021, p. 2). Recent population bottlenecks do not appear to be a concern, based on the relative consistency of levels of genetic diversity found in recent studies (McGlaughlin and Naibauer 2021, p. 22).

Stressors to the Colorado hookless cactus remain a concern for the viability of both species. Stressors that have species-level impacts currently include livestock use, invasive species, oil and gas development, off-highway vehicle (OHV), development and maintenance of utility corridors, and climate change. Both species have persisted in areas of light grazing or other disturbance. To minimize the influence of stressors on the species, the BLM has developed management measures on BLM lands (which encompasses 71 percent of both species' AUs, combined) to avoid or ensure minimal impacts to both Colorado hookless cactus species.

CHAPTER 5: FUTURE CONDITIONS

5.1 DEVELOPMENT OF FUTURE SCENARIOS

In this chapter, we forecast the resiliency of *S. glaucus* and *S. dawsonii* AUs and the redundancy and representation of each species to the year 2050 using a range of plausible future scenarios. We selected this timeframe because it is short enough for us to realistically predict changes in climate conditions and species stressors, yet long enough to be biologically meaningful to the species and to begin to understand the response of ecosystems to those changes. We used future climate models downscaled to the ranges of the species, in combination with forecasted changes in the location and intensity of stressors, to develop three future scenarios and evaluate the condition of the species under each of those scenarios. Since many of the stressors that affect *S. glaucus* and *S. dawsonii* occur on BLM lands, future scenarios were developed with input from the BLM about likely changes in the location and intensity of stressors on BLM land. Given

some level of uncertainty about the conditions that will actually be present in 2050, these scenarios represent optimistic, continuation, and pessimistic future conditions to capture the plausible range of future conditions the species may experience. Therefore, our evaluation of future conditions present a plausible range of expected species responses. While the metrics used to assess the current resiliency of *S. glaucus* and *S. dawsonii* AUs are quantitative, we do not have a reliable way to quantitatively forecast these metrics into the future. Instead, future conditions are expressed qualitatively, using the results of our Current Conditions (Chapter 4) as the baseline. Species experts used professional judgement to predict how the species and their habitats would respond to each future scenario (Krening 2021a, pers. comm.).

5.2 Climate Scenarios

We used available historic data and modeled future climate data obtained from the North Central Climate Adaptation Science Center, the Cooperative Institute for Research in Environmental Sciences, and the Climate Toolbox (Hegewisch 2020; North Central 2021, p. 1) to develop future climate scenarios. Using data from 1979–2000, we obtained a baseline of climate conditions in the ranges of *S. glaucus* and *S. dawsonii* in western Colorado. We then selected three future climate models that represent the range of projected future climate conditions in the area: warm and wet; moderately hot; and hot and dry (Table 13).

*Table 13. Historic and projected climate scenarios for the S. glaucus and S. dawsonii species ranges in western Colorado. *Summer is represented by the months of June, July, and August. **Values for the year 2050 are represented by the mean of years 2040-2069.*

Historic: 1979-2000			
Mean Summer* Water Deficit (in/cm)	17.9/45.4		
Year: 2050**			
	Warm and Wet	*Moderately Hot*	*Hot and Dry*
Mean Summer* Water Deficit (in/cm)	17.6/44.6	18.6/47.3	20.8/52.7

5.3 Description of Future Scenarios

Table 14 describes the three future scenarios used to evaluate the plausible range of conditions *S. glaucus* and *S. dawsonii* may experience by 2050. By capturing a range of plausible future scenarios, we can assume that actual future conditions will likely fall somewhere between these projected scenarios.

Table 14. Three scenarios that represent the range of future conditions for S. glaucus and S. dawsonii in relation to the species' stressors.

Stressor	Scenario 1: Optimistic	Scenario 2: Continuation	Scenario 3: Pessimistic
Incompatible Livestock Use	Grazing intensity decreases in the Cactus Park, Devil's Thumb, Gunnison River East, Roan Creek, and Plateau Creek AUs as grazing permit renewal stipulations include reductions in the number of livestock and adjustments to the timing, duration, and season of livestock use in these AUs.	Grazing continues at current levels in all AUs, with potential to degrade habitat. The BLM addresses problem areas with corrective actions consistent with jurisdictional Resource Management Plans.	Grazing continues at current levels in all AUs, with potential to degrade habitat. No corrective action taken when issues are identified.
Invasive Plant Species	Passive restoration occurs by limiting grazing and OHV recreational use.	Invasive plant species occur in some areas of occupied and suitable habitat; agencies and project proponents implement invasive species prevention and management measures when soil-disturbing activities occur.	The effectiveness of invasive plant management is reduced due to increased invasive seed spread by OHV use, and invasive species treatments are not adequate to control new infestations.
OHV Recreational Use	Implementation of Travel Management Plan leads to route closures in the Devil's Thumb, Gunnison Gorge, Whitewater, Palisade, Dominguez-Escalante, North Fruita Desert, Plateau Creek, and Roan Creek AUs.	Routes are identified for closure, but fewer routes are closed by the year 2050 than in scenario 1. Impacts occur in all AUs from OHV use.	OHV impact increases in parts of the North Fruita Desert, Devil's Thumb, Gunnison Gorge, and Whitewater AUs.
Oil and Gas Development	Same as scenario 2	Oil and Gas development continues to occur in limited areas of the Roan Creek AU. Minimal additional development occurs in the Devil's Thumb and Plateau Creek AUs. Measures continue to be put in place for new development projects to avoid *S. glaucus* and *S. dawsonii* cactus individuals when possible. No oil and gas activity is permitted in the Cactus Park, Gunnison Gorge, and Gunnison River East AUs, nor the majority of the Dominguez-Escalante AU due to National Conservation Area stipulations. No oil and gas activity is permitted in the Little Book Cliffs Wilderness Study Area located within the Palisade AU.	Oil and gas development accelerates in the Roan Creek and Plateau Creek AUs
Utility Corridor Development and Maintenance	Same as scenario 2	Development occurs in the energy corridor that intersects the Whitewater, Devil's Thumb, and Cactus Park AUs. Maintenance and additional development occur in the North Fruita Desert, Plateau Creek, Roan Creek, and Palisade AUs. Maintenance of existing infrastructure occurs in the Gunnison River East, Cactus Park, Dominguez-Escalante, and Gunnison Gorge AUs, with no new development in these AUs. Within the Whitewater and North Fruita Desert AUs, utility access routes attract public users, causing habitat damage.	Development increases in the energy corridor that intersects the Whitewater, Devil's Thumb, and Cactus Park AUs. Development also increases along the I-70 corridor in the Palisade AU. Additional pipelines are built in the Roan Creek and Plateau Creek AUs. An existing powerline is replaced with a larger structure in the Devil's Thumb and Whitewater AUs to increase capacity, causing significant ground disturbance.
Effects of Global Climate Change*	Warm and wet	Moderately hot	Hot and dry

5.4 SCENARIO 1: OPTIMISTIC

In scenario 1, we anticipate a decrease in the intensity of grazing in the Cactus Park, Devil's Thumb, Gunnison River East, Roan Creek, and Plateau Creek AUs. The BLM, by policy (43 CFR 4180.2) and practice is required to meet Land Health Standards. As such, in this scenario, we anticipate grazing permit renewals to include reductions in the number of livestock and adjustments to the timing, duration, and season of livestock use in these AUs, resulting in a reduction of livestock pressure (Lincoln and Holsinger 2021, pers. comm.).

In scenario 1, we also anticipate OHV use to decrease in the Devil's Thumb, Gunnison Gorge, Whitewater, Palisade, Dominguez-Escalante, North Fruita Desert, Plateau Creek, and Roan Creek AUs due to route closures as the BLM implements the Grand Junction Field Office Travel Management Plan (BLM 2015, Appendix M) and Uncompahgre Field Office Resource Management Plan (RMP) (BLM 2020, p. 3:108-3:113). Of 1,621 miles of existing routes in the jurisdiction of the BLM Grand Junction Field Office, the BLM has identified 315.2 miles of routes to close or limit types of recreational use, and 144.2 miles to restrict to administrative or authorized/permitted use only (Lincoln 2021, pers. comm.). Many of these routes are either duplicative or are located in sensitive habitats, and route closures will continue to be implemented through signage, physical barriers, and route restoration, including mechanical ripping and seeding. Route closures in the Devil's Thumb and Gunnison Gorge AUs will be guided by the applicable RMPs. While the RMPs do not designate specific routes for closure, the RMP that applies to Devil's Thumb does set criteria for future route designation (BLM 2020, p. 3:109). Routes and levels of acceptable use in Gunnison Gorge will be refined with assistance and input from the public and other agencies (BLM 2004, p. 2:26). OHV route closures and decreased grazing pressure will allow for passive habitat restoration, including areas where invasive plant species occur or have potential to be introduced.

In this scenario, oil and gas development and periodic utility corridor development continue in the same extremely limited trajectory that is currently occurring across the range of the species. No oil and gas activity is permitted in the Cactus Park, Gunnison Gorge, and Gunnison River East AUs, and the majority of the Dominguez-Escalante AU, due to National Conservation Area stipulations. Likewise, no oil and gas activity is permitted in the Little Book Cliffs Wilderness Study Area located within the Palisade AU. There is potential for additional oil and gas development in the Devil's Thumb and Plateau Creek AUs, though development is expected to be minimal. Little to no oil and gas development is expected in the North Fruita, Whitewater, and Palisade AUs. The Roan Creek AU currently has the most existing infrastructure, and development in this AU is expected to continue into the future. All new oil and gas projects requiring a permit from the BLM will include *S. glaucus* and *S. dawsonii* avoidance measures to protect individuals of the species when possible. The Whitewater, Devil's Thumb, and Cactus Park AUs intersect designated West-wide Section 368 Energy Corridors (West-wide n.d., entire), and development is expected to continue in these AUs over time. New development, as well as maintenance of existing infrastructure, is also expected in the North Fruita Desert, Plateau Creek, Roan Creek, and Palisade AUs. In this scenario, no new development is anticipated in the Gunnison River East, Cactus Park, Dominguez-Escalante, or Gunnison Gorge AUs. However, maintenance of existing infrastructure will occur here. In the Whitewater and North Fruita

Desert AUs, utility routes attract public recreationalists, which is expected to continue to cause localized impacts to habitat in this scenario.

In the optimistic scenario, the climate will be warm and wet, with summer water deficit decreasing slightly compared to the historic mean, meaning more water is readily available for the species. Table 15 outlines the future condition of the species we would expect in this scenario.

*Table 15. Analysis of future conditions for S. glaucus and S. dawsonii under the Optimistic scenario. *Note: A larger water deficit value equates to less water availability; resiliency increases as water deficit decreases. In this table, "High" ratings in the water deficit category refer to high resiliency rather than a large water deficit value.*

Optimistic Scenario						
Analytical Units		Habitat Needs	Demographic / Distribution Factors		Climate	Analytical Unit Resiliency
		Habitat Condition Index	Species-level Survival	Minimum Population Size (90% LCL)	Summer Water Deficit*	
S. glaucus	Whitewater	High	High	High	High	High
	Palisade	Moderate		Low	High	Moderate
	Dominguez-Escalante	High		High	High	High
	North Fruita Desert	Moderate		Moderate	High	High
	Devil's Thumb	High		High	High	High
	Cactus Park	High		High	High	High
	Gunnison Gorge	Moderate		Moderate	High	High
	Gunnison River East	High		High	High	High
S. dawsonii	Plateau Creek	High	High	Moderate	High	High
	Roan Creek	High		High	High	High

In the Optimistic scenario, resiliency of the Plateau Creek and Devil's Thumb AUs increases slightly. Decreases in activities such as grazing and OHV use that degrade *S. glaucus* and *S. dawsonii* habitat allow for passive restoration, which lead to improved habitat conditions in the Plateau Creek AU and an increase in population size in the Devil's Thumb AU. Summer water deficit is expected to slightly decrease, meaning more water is available for germination, growth, and reproduction. With only two *S. dawsonii* AUs, redundancy and representation are considerably lower than for *S. glaucus*, but redundancy and representation for this species increase under this scenario, as compared to current condition, due to an increase in resiliency in the Plateau Creek AU. Redundancy and representation of *S. glaucus* also increase under this scenario due to an increase in resiliency in the Devil's Thumb AU.

5.5 SCENARIO 2: CONTINUATION OF CURRENT CONDITIONS

In scenario 2, we analyze the expected responses of *S. glaucus* and *S. dawsonii* in a scenario that assumes a Continuation of Current Conditions (Table 13). In this scenario, grazing continues at current levels in all AUs, with potential to degrade habitat. The BLM addresses problem areas with corrective actions consistent with jurisdictional RMPs (BLM 2004, Appendix B; BLM 2015, p. 87-92; BLM 2020, p. 11:55-11:58). Unlike scenario 1, there are no reductions in the number of livestock or the amount of time that livestock spends grazing these areas; therefore, habitat is slower to recover than in scenario 1.

Recreational routes are identified for closure, and the BLM will continue to close routes as part of RMP implementation; however, as the closure process takes time and resources, fewer routes are closed by the year 2050 than in scenario 1. Localized impacts continue to occur in all AUs from OHV use, especially since some recreational users do not abide by route closures.

Invasive plant species occur in some areas of occupied and suitable habitat. Agencies, partners, and project proponents implement invasive species prevention and management measures when soil-disturbing activities occur, or when infestations are identified. Weed treatments continue, as control is more achievable than eradication. Unlike scenario 1, areas with continued pressure and disturbance from grazing and OHV use do not allow passive restoration to occur.

Oil and gas development and utility corridor development in this scenario occur in the same extremely limited capacity as in the optimistic scenario. No oil and gas activity is permitted in the Cactus Park, Gunnison Gorge, and Gunnison River East AUs, nor the majority of the Dominguez-Escalante AU, due to National Conservation Area stipulations. Likewise, no oil and gas activity is permitted in the Little Book Cliffs Wilderness Study Area located within the Palisade AU. There is potential for additional oil and gas development in the Devil's Thumb and Plateau Creek AUs, though development is expected to be minimal. Little to no oil and gas development is expected in the North Fruita, Whitewater, and Palisade AUs. The Roan Creek AU currently has the most existing infrastructure, and development in this AU is expected to continue into the future at a relatively slow pace, as seen over the past decade. All new oil and gas projects requiring a permit from the BLM will include *S. glaucus* and *S. dawsonii* avoidance measures to protect individuals of the species when possible. The Whitewater, Devil's Thumb, and Cactus Park AUs intersect designated West-wide Section 368 Energy Corridors (West-wide n.d., entire), and sporadic development is expected to continue in these AUs. New development, as well as maintenance of existing infrastructure, is also expected in the North Fruita Desert, Plateau Creek, Roan Creek, and Palisade AUs. In this scenario, no new development is anticipated in the Gunnison River East, Cactus Park, Dominguez-Escalante, or Gunnison Gorge AUs. However, maintenance of existing infrastructure will occur here. In the Whitewater and North Fruita Desert AUs, utility routes attract public recreationalists, which is expected to continue to cause localized impacts to habitat in this scenario.

In the continuation scenario, the climate will be moderately hot. Summer water deficit increases slightly compared to the historic average, meaning less water is readily available for the species. However, the summer water deficit still falls within one standard deviation of the historic mean. Table 16 outlines the future condition of the species that we would expect in this scenario.

*Table 16. Analysis of future conditions for S. glaucus and S. dawsonii under the Continuation of Current Conditions scenario. *Note: A larger water deficit value equates to less water availability; resiliency increases as water deficit decreases. In this table, "High" ratings in the water deficit category refer to high resiliency rather than a larger water deficit value.*

Continuation Scenario						
Analytical Units		Habitat Needs	Demographic / Distribution Factors		Climate	Analytical Unit Resiliency
		Habitat Condition Index	Species-level Survival	Minimum Population Size (90% LCL)	Summer Water Deficit*	
S. glaucus	Whitewater	High	High	High	High	High
	Palisade	Moderate		Low	High	Moderate
	Dominguez-Escalante	High		High	High	High
	North Fruita Desert	Moderate		Moderate	High	High
	Devil's Thumb	High		Moderate	High	High
	Cactus Park	High		High	High	High
	Gunnison Gorge	Moderate		Moderate	High	High
	Gunnison River East	High		High	High	High
S. dawsonii	Plateau Creek	Moderate	High	Moderate	High	High
	Roan Creek	High		High	High	High

In the Continuation scenario, we expect resiliency, redundancy, and representation to remain relatively unchanged from the current condition. Resiliency of the Palisade AU is moderate; resiliency of all other AUs are high. Despite the increase in summer water deficit as compared to historic conditions, this slight decrease in water availability would have minimal impact, since it is well within the range of variability that the species have historically experienced. Representation is comparable among *S. glaucus* and *S. dawsonii* and does not change in this scenario compared to the current condition. The eight AUs of *S. glaucus* plants are distributed broadly across the range of the species, providing redundancy throughout its relatively small geographic range. With only two AUs, redundancy of *S. dawsonii* is limited. However, the plausibility of catastrophic events also influences species' redundancy; if catastrophic events are unlikely within the range of the species, catastrophic risk is inherently lower. We are unaware of any plausible activity or naturally occurring event that would constitute a catastrophic event for either species. For example, fire is not a common occurrence in *S. glaucus* or *S. dawsonii* habitat as this habitat lacks the fuels to sustain a burn. Additionally, the range of both species contain natural and manmade barriers (i.e., rivers, canyons, highways) that would prevent the spread of any catastrophic fire throughout the entire range of the species.

5.6 Scenario 3: Pessimistic

In scenario 3, grazing continues at its current levels in all AUs. No corrective action is taken when issues are identified.

Impacts from OHV use increase in parts of the North Fruita Desert, Devil's Thumb, Gunnison Gorge, and Whitewater AUs, as the number of recreational users increases. This is most noticeable in the North Delta OHV area in the Devil's Thumb AU, the Peach Valley OHV area in the Gunnison Gorge AU, and throughout the North Fruita Desert and Whitewater AUs.

In this scenario, although agencies and project proponents implement invasive species prevention and management measures when soil-disturbing activities occur, the effectiveness of invasive plant management is reduced due to increased invasive seed spread by OHV use, and weed treatments are not adequate to control new infestations. Although wildfires are not common in the ecological region's natural state, invasive species, such as cheatgrass, could increase the risk of wildfire.

In this scenario, new oil and gas development is permitted in the Roan Creek and Plateau Creek AUs; these AUs overlie geologic formations in the Piceance Basin known to have high potential for natural gas extraction.

In the pessimistic scenario, utility corridor development increases in the Whitewater, Devil's Thumb, and Cactus Park AUs that intersect the designated West-wide Section 368 Energy Corridors. Development also increases along the I-70 corridor in the Palisade AU. As demand for oil and gas increases, additional pipelines are built in the Roan Creek and Plateau Creek AUs. Finally, in this scenario, the structures of an existing powerline in the Devil's Thumb and Whitewater AUs are replaced with larger structures to increase capacity, causing significant ground disturbance.

Projected climate conditions in this scenario are hot and dry; summer water deficit is greater than one standard deviation from the historic mean. Table 17 outlines the future condition of the species that we would expect in this scenario.

Table 17. Analysis of future conditions for S. glaucus and S. dawsonii under the Pessimistic scenario.

Pessimistic Scenario						
Analytical Units		Habitat Needs	Demographic / Distribution Factors		Climate	Analytical Unit Resiliency
		Habitat Condition Index	Species-level Survival	Minimum Population Size (90% LCL)	Summer Water Deficit	
S. glaucus	Whitewater	Moderate	Moderate	High	Moderate	Moderate
	Palisade	Low		Low	Moderate	Low
	Dominguez-Escalante	High		High	Moderate	High
	North Fruita Desert	Low		Moderate	Moderate	Moderate
	Devil's Thumb	High		Moderate	Moderate	Moderate
	Cactus Park	Moderate		Moderate	Moderate	Moderate
	Gunnison Gorge	Low		Moderate	Moderate	Moderate
	Gunnison River East	High		Moderate	Moderate	Moderate
S. dawsonii	Plateau Creek	Moderate	High	Moderate	Moderate	Moderate
	Roan Creek	High		High	Moderate	High

In this scenario, hot and dry conditions may cause a negative effect on survivorship and recruitment of the species. Summer water deficit is more than one standard deviation from the historic mean, meaning that on average, less water is available to support germination, growth, and reproduction. Under the Pessimistic scenario, an increase in ground disturbance and habitat degradation caused by grazing, OHV use, oil and gas development, utility corridor development, and an increase in invasive plant species negatively affects the amount and quality of habitat available and reduce survival rates and overall population sizes, leading to a decrease in resiliency in the Whitewater, Palisade, North Fruita Desert, Devil's Thumb, Cactus Park, Gunnison Gorge, Gunnison River East, and Plateau Creek AUs. Redundancy and representation of *S. glaucus* decrease slightly due to the decrease in resiliency in all but one AU; however, even in the most pessimistic plausible scenario, all AUs are expected to remain extant, thereby preserving redundancy and representation. Despite high and moderate resiliency of the two *S. dawsonii* AUs, representation and redundancy is lower than under scenarios 1 and 2 and current condition, due to overall moderate (rather than high) condition in Plateau Creek. With only two known *S. dawsonii* AUs, the loss of one of these AUs due to catastrophic, natural, or human-caused events would cause a severe loss of redundancy and representation of the species, though a complete loss of either AU is not expected, even in a Pessimistic scenario. Additionally, the plausibility of catastrophic events also influences species' redundancy; if catastrophic events are unlikely within the range of the species, catastrophic risk is inherently lower. We are unaware of any plausible activity or naturally occurring event that would constitute a catastrophic event for either species. For example, fire is not a common occurrence in *S. glaucus* or *S. dawsonii* habitat as this habitat lacks the fuels to sustain a burn, though increased invasive species presence could elevate this risk. Additionally, the range of both species contain natural and manmade barriers (i.e., rivers, canyons, highways) that would prevent the spread of any catastrophic fire throughout the entire range of the species.

CHAPTER 6: SSA SUMMARY

In this SSA, we describe the ecological needs of *S. glaucus* and *S. dawsonii*, identify stressors on the species and conservation efforts, assess the current condition of each species, and analyze the effects of plausible future scenarios on the viability of each species.

The most recent genetic studies identified three distinct regional groups of Colorado hookless cactus: Northern (near DeBeque, CO), Grand Valley, and Gunnison River groups (Schwabe *et al*. 2015, p. 447; McGlaughlin 2017, p. 5). Genetic analyses using Random Site-Associated DNA sequencing (RADseq) determined that the Northern group should be recognized as a distinct species, *S. dawsonii* (McGlaughlin and Naibauer 2021, p. 3). The Grand Valley and Gunnison River groups share connectivity and form a genetically cohesive group, which represents a second distinct species of *Sclerocactus* (collectively *Sclerocactus glaucus*) (McGlaughlin and Naibauer 2021, p. 3). Based on these novel genetic discoveries, this SSA assesses the current and future condition of Colorado hookless cactus as two separate entities: *S. glaucus* and *S. dawsonii*.

Stressors include livestock use, invasive species, oil and gas development, OHV recreational use, predation, development and maintenance of utility corridors, and the effects of global climate change. Other stressors include herbicide and pesticide application; collection and commercial trade. Predation; herbicide and pesticide application; and collection and commercial trade but are limited to individual-level effects and do not influence Colorado hookless cactus at the AU or species level; therefore, they were not carried forward in our SSA analyses of current and future conditions. To minimize stressors to the species, several local, state, and Federal agencies, organizations, and volunteers have contributed to the conservation of the species through special land management designations and the incorporation of conservation measures in land management plans.

Both of the two *S. dawsonii* AUs and seven of the eight AUs of *S. glaucus* currently have high resiliency. Range-wide monitoring efforts have demonstrated a stable trend over recent years and have also provided a detailed understanding of demographic features and population dynamics. Across their limited ranges, both species of Colorado hookless cactus are relatively abundant, which contribute to the high levels of resiliency in all but one AU. Redundancy for narrow endemic species is inherently limited; however, *S. glaucus* plants are distributed broadly across the range of the species in eight AUs, providing redundancy throughout its relatively small geographic range. With only two AUs located within a smaller range than *S. glaucus*, redundancy of *S. dawsonii* is much lower than that of *S. glaucus*. *S. glaucus's* relatively broad distribution and multiple highly resilient AUs make it better able to withstand catastrophic events than *S. dawsonii*. Representation is comparable among *S. glaucus* and *S. dawsonii*. Both species exhibit some ecological and morphological variability, coupled with low to moderate genetic diversity among AUs. However, inbreeding is not an immediate concern for either species.

In a Pessimistic future scenario, future development, and incompatible uses of *S. glaucus* and *S. dawsonii* habitat have the potential to reduce the resiliency of most AUs. A hot and dry climate scenario could also reduce resiliency, although we are unsure to what extent. With only two known *S. dawsonii* AUs, the loss of one of these AUs due to catastrophic, natural, or human-

caused events would cause a severe loss of redundancy and representation of the species, though a complete loss is not expected even in a Pessimistic scenario. Under Optimistic and Continuation scenarios, resiliency is expected to remain high for both *S. dawsonii* AUs and seven of the eight *S. glaucus* AUs. Redundancy and representation are inherently low in narrow endemic species; however, even in our most pessimistic scenario, we anticipate all AUs of both species to remain extant, thereby preserving representation and redundancy of each species.

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APPENDIX 1: Habitat Condition Index

Table A1. Habitat Condition Index Detailed Thresholds (numerical value in parentheses next to "High," "Moderate," or "Low" indicates the number of points an AU receives for a rating in that threshold for a particular category). The overall habitat score is calculated by averaging the number of points an AU receives for each of the five categories.

THRESHOLDS	Quality			Size	Type	Habitat Score
	Invasive Species Cover	Bare Ground	Native Perennial Cover	Proportion of area (%)	Acres of available moderate to high habitat probability	
High	HIGH (1) = the interquartile range (0–2.7% invasive species cover)	HIGH (1) = the interquartile range (10-36% bare soil)	HIGH (1) = median – 95% quartile (27-63% native perennial cover)	HIGH (3) = >11% of the overall species area	HIGH (3) = if >65% of the analytical unit area fell into the high or moderate output categories from the model	HIGH = 1.41 - 1.8
Moderate	MODERATE (0.666) = 75-85% quartile (2.7-5.8% invasive species cover)	MODERATE (0.666) = 5-10% and 36-55% bare soil	MODERATE (0.666) = 25% - median and 95-100% quartile (17-27% and >63% native perennial cover)	MODERATE (2) = 6-10% of the overall species area	MODERATE (2) = if 45-65% of the analytical unit area fell into the high or moderate categories	MODERATE = 1.01 - 1.4
Low	LOW (0.333) = >85% quartile (>5.8% invasive species cover)	LOW (0.333) = 0-4% and >55% bare soil	LOW (0.333) = <25% quartile (0-17% native perennial cover)	LOW (1) = <6% of the overall species area	LOW (1) = if <45% of the analytical unit area fell into the high or moderate categories	LOW = 0.6 - 1.00

Table A2. Habitat Condition Index Ratings for Each AU

Habitat Condition Index							
Analytical Units		Quality			Size	Type	Habitat Score
		Invasive Species Cover	Bare Ground	Native Perennial Cover	Proportion of area (%)	Acres of available moderate to high habitat probability	
S. glaucus	Whitewater	LOW	MODERATE	HIGH	HIGH (15%)	HIGH	HIGH (1.60)
	Palisade	HIGH	HIGH	HIGH	LOW (2%)	MODERATE	MODERATE (1.20)
	Dominguez-Escalante	HIGH	HIGH	HIGH	HIGH (17%)	HIGH	HIGH (1.80)
	North Fruita Desert	LOW	LOW	LOW	MODERATE (10%)	HIGH	MODERATE (1.20)
	Devil's Thumb	HIGH	HIGH	HIGH	HIGH (13%)	HIGH	HIGH (1.80)
	Cactus Park	MODERATE	MODERATE	MODERATE	HIGH (6%) *	HIGH	HIGH (1.60)
	Gunnison Gorge	MODERATE	HIGH	MODERATE	MODERATE (6%)	MODERATE	MODERATE (1.27)
	Gunnison River East	HIGH	HIGH	HIGH	HIGH (8%) *	HIGH	HIGH (1.80)
S. dawsonii	Plateau Creek	LOW	MODERATE	HIGH	MODERATE (10%)	HIGH	MODERATE (1.40)
	Roan Creek	LOW	HIGH	HIGH	HIGH (13%)	HIGH	HIGH (1.67)
	* If a population ranked as either "moderate" or "low" based on this criterion but was contiguous with one or more other populations that received a higher ranking, we elevated its ranking one level.						